PB98-964606
EPA 541-R98-063
October 1998

EPA Superfund
Record of Decision:

Tulalip Landfill
Marysville, WA
9/29/1998

FINAL
RECORD OF DECISION

TULALIP LANDFILL SUPERFUND SITE
ON-SOURCE AND OFF-SOURCE
REMEDIAL ACTION

MARYSVILLE, WASHINGTON

SEPTEMBER 1998

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 10

DECLARATION FOR THE RECORD OF DECISION

Site Name and Location

Tulalip Landfill Superfund Site
Marysville, Washington

Statement of Basis and Purpose

This decision document presents the selected final remedial action for the Tulalip Landfill Superfund Site near Marysville, Washington, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the administrative record file for the site. The landfill, including most of the off-source area, is located within the boundary of the Tulalip Indian Reservation. The Tulalip Tribes of Washington concur with the selected remedy.

Assessment of the Site

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action for the on-source and off-source areas as selected in this ROD, may present an imminent and substantial endangerment to human health, welfare, or the environment.

Description of the Selected Remedy

This Record of Decision (ROD) selects the final remedy for both the on-source and off-source areas of the site.

1. On-source Remedy (from the March 1996 Interim ROD)

The on-source remedy presented in the March 1, 1996, Record of Decision (ROD) entitled Tulalip Landfill Superfund Site Interim Remedial Action Marysville, Washington is the final remedy for the on-source area. The remedy previously documented in the March 1996 interim ROD was designed to protect human health and the environment by containing and preventing contact with the landfill wastes. Major elements of the final remedy include:

- Capping the landfill in accordance with the Washington State Minimum Functional Standards (MFS) for landfill closure.
- Installing a landfill gas collection system. If necessary, a gas treatment system will also be installed.
- Monitoring the leachate mound within the landfill, the

perimeter leachate seeps, and landfill gas to ensure the selected remedy is adequately containing the landfill wastes.

- Restrictions to protect the landfill cap.

- Providing for operation and maintenance (O&M) to ensure the integrity of the cap system.

The selected on-source remedy is expected to stem the migration of contaminants from the landfill into the surrounding estuary by minimizing the amount of rain water infiltrating the wastes, thereby minimizing the generation of new leachate. With the finalization of this remedy, *no further remedial action is necessary* for the on-source area.

The remedial design for the on-source cover system was completed on May 6, 1998. Construction of the cover system began on June 18, 1998, and will take approximately 2 years to complete.

2. Off-source Remedy

The remedy for the off-source area (wetlands) documented in this ROD was designed to protect human health and the environment through the continued implementation of institutional controls. The major element of the off-source remedy selected in this ROD is to:

- Place and maintain an adequate number of signs to prohibit access to contaminated wetland areas and the consumption of fish and shellfish from those areas.

Statutory Determinations (Declaration Statement)

The selected on-source and off-source remedial actions are protective of human health and the environment, comply with Federal, State, and Tribal requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost-effective. These remedial actions utilize permanent solutions and alternative treatment technologies to the maximum extent practicable for this site. However, the presumptive remedy approach for municipal landfills selected in the interim ROD utilizes the remedial approach of containment of wastes rather than treatment of wastes. Because treatment of the principal threats at the site was not found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principal element of the remedy.

Because this remedial action will result in hazardous substances remaining on the site above health-based levels, a statutory review will be conducted no less often than every five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Chuck Clarke

Chuck Clarke
Regional Administrator
U.S. EPA Region 10

9/29/98

Date

TABLE OF CONTENTS

1.0 SITE DESCRIPTION

1.1 Physical Description of the Landfill (Source Area)

The Tulalip Landfill Superfund Site (site) consists of a source area and an off-source area. The Tulalip Landfill source area occupies approximately 147 acres and is located on North Ebey Island in the Snohomish River delta. Located within the bounds of the Tulalip Indian Reservation, the landfill lies generally between Marysville and Everett, Washington (**Figure 1**). North Ebey Island is bounded to the north by Ebey Slough and to the south by Steamboat Slough. The island is located in Snohomish County, Township 30N, Range 5E, Section 32. The residences closest to the landfill are north of Ebey Slough and the nearest residence is located approximately 600 feet from the landfill perimeter.

Prior to landfilling activities, the land on which the landfill is located consisted of relatively undisturbed intertidal wetlands. During landfilling operations, barge canals were cut into the island to allow barges bearing refuse to transport waste into the landfill. Initially, waste was removed from the barges and placed directly on top of adjacent wetlands. During later operations waste was placed into the canals.

The average depth of waste throughout most of the landfill is about 17 feet. In the old barge canals the fill depth reaches about 30 feet. Three to four million tons of mixed commercial and industrial waste were deposited in the landfill during its period of operation from 1964 to 1979.

The landfill was subsequently closed and a berm was constructed around most of the perimeter of the landfill. The surface of the landfill was graded and cover soils were placed over it. However, insufficient grading of this cover material resulted in poor drainage and allowed precipitation to pond and eventually infiltrate the landfill surface. As a result, a mound of contaminated groundwater (leachate) formed within the landfill.

Due to the difference in elevation between the leachate mound and the groundwater level, the weight of the leachate mound forces leachate down into the groundwater and out of the landfill into the surrounding wetlands and tidal channels. The majority of the leachate migrates out of the landfill and into surrounding waterways. However, a portion of this leachate (5 to 35 percent) escapes the confines of the landfill and is discharged to the landfill's surrounding wetlands through a series of seeps, the majority of which are located along the perimeter of the landfill berm.

The volume of discharge from these perimeter seeps is directly influenced by the amount of precipitation received by the landfill area. Leachate is discharged in visibly greater amounts during the wet season due to the increased height of the leachate mound within the landfill. Conversely, some of the perimeter leachate seeps cease to flow entirely during the dry season due to low levels of precipitation received by the landfill.

Groundwater beneath the site is brackish and therefore unusable as a potable water source. Site studies indicate that contaminated groundwater from the landfill migrates to the wetlands and sloughs surrounding the site and does not pose a threat to groundwater drinking water sources located across the sloughs.

1.2 Off-Source Area (Wetlands)

The off-source area refers to the wetlands and tributaries adjacent to the berm and bounded by Ebey and Steamboat Sloughs (**Figure 2**). Site access is currently restricted, and the wetlands adjacent to the west of the site remain relatively undisturbed by human activity.

A 1995 wetland delineation and functional assessment[1] of the off-source area identified 242 acres of tidal wetlands including three general types of habitats: high estuarine wetlands; salt marsh; and mudflats. These wetlands have an important environmental role in the Snohomish River delta as sources and sinks for nutrients, sediment retention areas, and habitat transition zones, and provide unique ecosystems that support highly diverse and abundant wildlife species.

One of the most important functions of the wetlands is that they provide nursery areas for many fish and wildlife species. Species that live in the wetlands around the landfill include shorebirds and waterfowl, marsh hawk, coyote, otter, deer, salmon, cutthroat trout, clams, mussels, and juvenile Dungeness crab. Both the bald eagle and the northern sea lion are considered threatened under State and Federal law and have either been observed in the vicinity of the site or may be expected to use the habitat areas near the landfill.

---

[1] Weston. Draft Tulalip Landfill Wetland Delineation and Functional Assessment. Prepared for U.S. Environmental Protection Agency. November 1995.

The landfill is located within the Puget Sound Estuary, one of 28 estuaries in the country that have been targeted for protection and restoration under the National Estuary Program, which was established by Congress in 1987 as part of the Clean Water Act. The State of Washington has classified the surface waters surrounding the site as "Class A" waters of the State, which are characterized as generally "excellent" waters, where water quality meets or exceeds the requirements for all, or substantially all, designated uses.

The tidal mudflats and marsh habitats surrounding the landfill are natural resources that provide spawning and foraging areas for wildlife species. The Snohomish River delta is designated as a Washington Shoreline of Statewide Significance by the Washington State Department of Ecology, and designated as an Area of Major Biological Significance for American shad and English sole by the U.S. Fish and Wildlife Service.

The Tulalip Landfill is situated within this ecologically valuable ecosystem. Contaminated leachate from the landfill discharges directly into wetlands that carry on critical habitat functions. Over the years, human activities have increasingly led to the destruction and degradation of such wetland areas within the Snohomish River delta. As such wetland resources become more scarce, the importance of protecting and preserving the remaining areas for future generations becomes crucial. The results of the streamlined baseline Risk Assessment for Interim Remedial Action (the "Streamlined Risk Assessment") indicate that the landfill acts as a chronic source of contamination to the surrounding environment, and that ongoing chemical discharges from the Tulalip Landfill are resulting in potentially harmful effects to animals living on and around the landfill.

2.0 SITE HISTORY AND ENFORCEMENT ACTIONS

2.1 The Tulalip Tribes of Washington

The Tulalip Tribes of Washington (the Tribes) is a federally recognized Indian Tribe organized under Section 16 of the Indian Reorganization Act of 1934, as amended, 25 U.S.C. § 476. The lands on which the landfill is located are held by the United States in trust. In 1936, the Tribes established the Tulalip Section 17 Corporation, as a federal corporation chartered pursuant to Section 17 of the Indian Reorganization Act, 25 U.S.C. § 477.

2.2 Operation of the Landfill 1964-1979

In 1964, the Tulalip Section 17 Corporation leased the landfill site to the Seattle Disposal Company (SDC) for a 10-year period. A second lease was executed in 1972. From 1964 to 1979, SDC operated the landfill under the direction of its general partners, Josie Razore, John Banchero, and Alphonso Morelli. The site handled commercial and industrial waste. Between 1964 and 1979, it is reported that approximately three to four million tons of mixed commercial and industrial waste was deposited in the landfill.

Because of ongoing environmental problems associated with the landfill operations, the landfill was closed in 1979. The closure, fully funded by SDC, required the construction of a perimeter berm around the landfill waste disposal area, and placement of cover soils after final grading of the surface.

2.3 Operations at the Landfill after 1985

In 1985, the Tulalip Tribes of Washington sought to place a thicker soil cap over the landfill to address ongoing leachate discharges at the site. In order to build a dock for delivery of materials to the landfill, the Tribes receive a dredge and fill permit pursuant to the Clean Water Act, 33 U.S. C. § 1342, from the Army Corps of Engineers in March 1986. EPA issued a five-year National Pollutant Discharge Elimination System ("NPDES") Permit in February of 1986, which allowed the placement of low permeability soils as approved by EPA, and required the collection of leachate.

The NPDES permit was subsequently modified to allow placement of demolition materials, as approved by EPA, for the construction of a road network for the capping project. Under contract with the Tribes, R.W. Rhine, Inc. brought capping materials from several demolition projects to the site to build that road network.

In 1990, EPA corresponded with the Tribes regarding the disposal of materials without EPA approval. In a letter, EPA recommended that the Tribes cease the voluntary capping effort, and comply with the NPDES permit requirement to collect leachate. In 1991, the Tribes wrote EPA that they would not apply to renew the NPDES permit.

2.4 The National Priorities List (NPL)

On July 29, 1991, EPA proposed adding the Tulalip Landfill to the National Priorities List (NPL). On April 25, 1995, with the support of the Governor of the State of Washington, EPA published the final rule adding the site to the NPL. In July

1995, SDC and the University of Washington filed petitions to challenge the NPL rule in the U.S. Court of Appeals for the District of Columbia. In June 1996, the Court issued its decision upholding the listing.

2.5 The Remedial Investigation and Feasibility Study

In August 1993, EPA signed an Administrative Order on Consent with several Potentially Responsible Parties to conduct a Remedial Investigation and Feasibility Study. These parties were Seattle Disposal Company, Marine Disposal, Josie Razore, John Banchero, Washington Waste Hauling and Recycling, Inc., Rubatino Refuse Removal, Inc., Monsanto Company, and the Port of Seattle.

Site investigation efforts showed that landfill leachate leaving the site exceeds water quality criteria and standards for several contaminants. This leachate flows directly into sensitive, ecologically valuable wetlands that surround the site, and into sloughs connected with the Snohomish River and Puget Sound. The RI documents the presence of hazardous substances in the soils, sediments, surface water, and groundwater at the site.

2.6 Citizen Suit under Clean Water Act and Resource Conservation and Recovery Act (RCRA)

On March 30, 1994, Josie Razore and John Banchero filed suit against the Tulalip Tribes of Washington, the Tulalip Section 17 Corporation, the Bureau of Indian Affairs (BIA) and Carol Browner, Administrator of the Environmental Protection Agency (EPA). The complaint alleged that the Tulalip Tribes of Washington, the Tulalip Section 17 Corporation, and the BIA were in violation of their NPDES permit and Section 301(a) of the Clean Water Act.

On September 23, 1994, the court dismissed the lawsuit, holding that the court was deprived of jurisdiction pursuant to CERCLA Section 113(h). The Plaintiffs appealed the dismissal to the U.S. Court of Appeals for the Ninth Circuit. The plaintiffs subsequently filed with the court an Appellants Memorandum of Emergency Motion for Injunction Pending Appeal, which cited testimony that leachate was discharging from the Tulalip Landfill site at levels exceeding water quality criteria. The plaintiffs' emergency motion was denied by the court. On September 19, 1995, the U.S. Court of Appeals for the Ninth Circuit filed an opinion upholding dismissal of the lawsuit.

2.7 Invocation of Dispute Resolution Under the 1993 AOC

On February 17, 1995, the Respondents to the 1993 Administrative Order on Consent (AOC) for the conduct of the

RI/FS invoked dispute resolution under Paragraph 61 of the AOC with respect to a number of issues. On October 18, 1995, EPA Region 10's Deputy Regional Administrator issued a final determination that resolved the issues.

2.8 Tulalip Landfill Interim ROD (March 1996)

In 1996 EPA published the record of decision for the Tulalip Landfill interim remedial action. The ROD selected capping to contain and prevent contact with landfill wastes. The selected remedy is expected to stem the migration of contaminants from the landfill into the surrounding estuary by minimizing the amount of rain water infiltrating the wastes, thereby minimizing the generation of new leachate.

2.9 Allocation Pilot Project

In February 1996, EPA entered into an agreement with 31 potentially responsible parties at the Tulalip Landfill Superfund site to participate in an allocation process to resolve parties' responsibility for cleanup costs. Since that time, all but two of the allocation parties entered into settlement agreements with the EPA and withdrew from the allocation process. A non-binding allocation recommendation was issued and one of the parties has reached agreement on terms for settlement with EPA.

2.10 Settlements With Potentially Responsible Parties

- Parties that contributed less than 1.0% documented waste volume to the site were identified as *de minimis* parties. Under three different Administrative Orders on Consent, finalized in 1996, 1997, and 1998, over 200 *de minimis* potentially responsible parties (PRPs) have settled and made payments to EPA.

- Under a Consent Decree entered by the United States District Court on March 18, 1998, Waste Management, Inc. agreed to design the cover system and with proceeds from the various settlements, construct the cover system. In the same Consent Decree the Tribes agreed to pay cash toward the settlement and to participate in the long-term maintenance of the cover system.

- Under a second Consent Decree entered by the United States District Court on March 18, 1998, Seattle Disposal Company agreed to pay cash towards the construction and maintenance of the cover system and other project costs.

- Under a third Consent Decree, also entered by the United States District Court on March 18, 1998, most of the remaining major PRPs agreed to pay cash toward the construction and maintenance of the cover system.

2.11 Comprehensive Baseline Risk Assessment for the Off-Source Area

The Comprehensive Baseline Risk Assessment (CBRA) was conducted to delineate and quantify potential current and future risks to human health and the environment in the off-source area of the Tulalip Landfill Superfund site. The CBRA was conducted assuming that the interim remedy, a cap over the landfill, was in place and fully functioning. The landfill cap is anticipated to eliminate leachate generation and discharge from the landfill within a few years following its completion, and thereby reduce contaminant loadings to the off-source area. The CBRA presents the results of each step in the risk assessment process including contaminant identification and screening, exposure assessment, toxicity assessment, risk characterization, and a discussion of uncertainties.

2.12 Focused Feasibility Study for the Off-source Area

The focused Feasibility Study[2] for the off-source area was prepared in May 1998. The purpose of this study was to evaluate potential cleanup alternatives for the off-source area of the Tulalip Landfill Superfund site.

3.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

CERCLA requirements for public participation include releasing the Remedial Investigation and Feasibility Study (RI/FS) Reports and the Proposed Plan to the public and providing a public comment period on the Feasibility Study and Proposed Plan. EPA published notice of the release of the RI/FS and the Proposed Plan for the on-source area on August 4, 1995. A public comment period was provided from August 4, 1995 to October 25, 1995. A detailed description of community relations activities through February 29, 1996, can be found in the interim ROD.

Since that time the following Superfund community relations activities have been conducted by EPA for the Tulalip Superfund site:

March 7, 1996	EPA released a fact sheet announcing the selected remedy described in the March 1, 1996, on-source ROD.

[2] Weston. Tulalip Landfill Off-Source Area Technical Evaluation of Potential Remedial Alternatives. Prepared for U.S. Environmental Protection Agency. May 1998.

July 9, 1996	EPA announced the start of a 30-day public comment period for the first group of *de minimis* parties in the Federal Register.
August 29, 1997	EPA announced the start of a 30-day public comment period for the second group of *de minimis* parties in the Federal Register.
October 6, 1997	DOJ released a notice in the Federal Register announcing the start of a 30-day public comment period on three consent decrees containing the settlement terms for most of the major parties.
March 26, 1998	EPA announced the start of a 30-day public comment period for the third group of *de minimis* parties in the Federal Register.
June 19, 1998	EPA mailed a fact sheet announcing that the design for the on-source cover system was finalized and that construction was beginning.
August 3, 1998	EPA released the Proposed Plan for the off-source area.
August 3, 1998	Newspaper ad ran in the Everett Herald announcing the public comment period on the Proposed Plan and the opportunity for a public meeting.
September 1, 1998	Comment period on Proposed Plan closed.

Selection of the final remedy is based on the Administrative Record. There are two copies of the Administrative Record available for public review. One copy is located at the EPA Region 10 office at 1200 Sixth Avenue, in Seattle, Washington. The second copy is located at the Marysville Public Library in Marysville, Washington.

4.0 SCOPE AND ROLE OF ACTION

EPA has divided the site remediation into two major phases. The first phase consists of remediating the 147 acre on-source area which is the principal risk at this site. The second phase of the remediation is to address contamination that may have migrated to the surrounding wetlands.

EPA has already selected an interim remedy for the on-source area as presented in the March 1, 1996, ROD entitled Tulalip Landfill Superfund Site Interim Remedial Action Marysville, Washington. EPA is now incorporating that remedy into this final ROD. The interim remedy was previously selected in order to contain contaminant concentrations that exceeded ecological and human health-based criteria, and in order to stop contaminant mass loading to the wetlands surrounding the landfill. With the finalization of this remedy, *no further remedial action is necessary* for the on-source area.

This document also presents the additional selected remedial action for the off-source (wetlands) area of the Tulalip Landfill Superfund Site, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

5.0 SITE CHARACTERISTICS

5.1 Data and Media Sampled

As part of the Tulalip Landfill Remedial Investigation (RI), various media including soils, sediment, surface water, groundwater (zones 1 and 2)[3], leachate, fish, and small mammals were sampled in order to assess contamination associated with the landfill. In addition, a clam bioassay and mussel bioaccumulation study were conducted. The RI documents the presence of hazardous substances in soil, sediment, surface water, groundwater (zones 1 and 2), leachate, fish, and small mammals from the source area, off-source area, and off-site areas, as well as in clams grown in the laboratory in off-source and off-site sediment. **Table A-1** contains a list of contaminants that were detected in different media. Many of the chemicals are common across media. For example, seventy chemicals found in leachate were also found in off-source soil, sediment, and/or surface water. Twenty-one of these chemicals were also detected in fish tissue. In addition, 53 chemicals found in leachate were also found in zone 2 groundwater which exits the landfill into

---

[3] Zone 1 encompasses the groundwater within the leachate mound located in the refuse layer of the landfill. Zone 2 is the deeper groundwater located below the refuse layer.

the adjacent sloughs. This pattern of shared chemicals among media suggests that there is a transport mechanism for chemicals from the landfill (source area) to off-source areas.

5.2 Release of Contaminants from the Landfill and Exceedances of Standards in Various Media

The primary mechanism by which contaminants are released from the buried refuse at the Tulalip landfill is leaching. The RI/FS shows that contaminated groundwater within the landfill (zone 1) migrates to surface water by way of leachate seeps on the outside surface of the landfill berm, and deeper groundwater (zone 2) that surfaces in adjacent sloughs. Leachate seeps, which generally discharge from the berm surrounding the landfill, discharge to surrounding soil/sediment and surface water. The highest concentrations of contaminants in surface soil were generally reported at the point of leachate seep discharge, and declined rapidly with distance from the leachate seep discharge.

The results of the Final Tulalip Landfill Risk Assessment for Interim Remedial Action[4] indicate that there are some exceedances of the site-specific comparison numbers in the leachate, groundwater, soil, and sediment samples from the site. These comparison numbers were established based upon human health and ecological standards, criteria, or risk-based concentrations that are generally considered to be protective of human health and the environment.

Of the media screened for human health, there were exceedances in leachate, off-source soil samples (surface and subsurface), sediment (surface and subsurface), and surface water. The highest number of exceedances were found in leachate and surface soil. The chemicals most frequently exceeding comparison numbers were arsenic, carcinogenic polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and pesticides. Chemicals measured in leachate seeps (arsenic, carcinogenic PAHs, PCBs, and pesticides) were at least 10 times higher than human health criteria (EPA ambient water quality criteria for fish consumption). Off-source sediment and soil exceeded criteria for arsenic (EPA Region III risk-based screening concentrations and Model Toxics Control Act (MTCA) cleanup standards). **Figure 3** identifies sampling locations, media, and contaminants for the most significant exceedances of the human health comparison numbers. Generally, all chemicals that exceeded comparison numbers in soil and sediment samples

---

[4] Weston. Final Tulalip Landfill Risk Assessment for Interim Remedial Action. Prepared for U.S. Environmental Protection Agency. August 1995.

were also detected in leachate seeping from the landfill surface and berm.

For the ecological evaluation, contaminants found in surface soils near six of the nine leachate seeps exceeded sediment quality standards (SQS). SQS are chemical concentrations in sediments above which adverse effects may occur to organisms exposed to the contaminated sediments. These values are established by the Washington State Department of Ecology for marine sediments in Puget Sound. Sediment values are considered appropriate for comparison to soil sample results because many of the soil sample locations are tidally influenced and tend to be saturated, and because the parent material of the surface soil in the off-source area is sediment. Contaminants found in leachate exceeded marine chronic criteria (MCC) ambient water quality standards at least once in most of the eleven seeps that were tested. Groundwater from zones 1 and 2 exceeded MCC for several contaminants including metals. The highest number of exceedances of ecological comparison numbers were found in leachate and surface soil. The chemicals most frequently found in exceedance of comparison numbers were PAHs, pesticides, and inorganics. Most of the surface soil samples exceeding criteria were associated with leachate seeps. **Figure 4** identifies sampling locations, media, and contaminants for the most significant exceedances of the ecological comparison numbers. Concentrations of chemicals detected in the high estuarine wetlands (HEW) and salt marsh soils did not exceed SQS. HEW and salt marsh soil sample locations are presented in **Figure 5**.

5.3 Sampling of Off-Site Media to Identify Background Level Contaminant Concentrations

As part of the RI, various off-site media including soil, sediment, surface water, fish, and clams grown in off-site sediment were sampled in an attempt to determine site-specific background contaminant concentrations. Samples were collected from the Quilceda Creek, Smith Island, and upstream sampling areas, which were believed to be relatively uncontaminated. Analysis of data from these off-site areas revealed a high number of organic compounds in soil and sediment in addition to the inorganic contaminants that would be expected to be present. The organic compounds included various semi-volatile organic compounds, PAHs, pesticides, and PCBs. The specific source or sources of the organic contaminants in background samples is not known. Given the dynamic nature of the estuary environment in the vicinity of the landfill (e.g., the area is influenced by tides, flooding, and the Snohomish River), off-site sampling locations could have been influenced by the Tulalip landfill, or by other potential sources in the area including non-point sources (e.g., runoff from residential areas, agricultural land, and highways) or local point sources (e.g., a sewage treatment plant and a pulp mill). No attempt was made to distinguish potential landfill contributions to the background samples from other potential sources as this activity was beyond the scope of the site RI.

In addition to the high number of organic compounds detected in off-site soil and sediment, excessive organism mortality in bioassays indicated that the off-site samples may not have been collected from relatively uncontaminated areas. Furthermore, all clam bioassay samples failed the performance criteria established in the Washington State Sediment Management Standards. Therefore, it was determined that the off-site data did not represent a relatively uncontaminated site-specific background area, and would not be used to differentiate site-related from naturally-occurring or ambient levels of contaminants, nor to screen contaminants of concern in the Comprehensive Baseline Risk Assessment (CBRA). Instead, Puget Sound regional sediment reference concentrations[5] were used for comparison to off-source sediment concentrations, and Washington State natural soil metals concentrations[6] were used for comparison to off-site soil concentrations.

5.4 Summary of the Off-source Area Contamination

The primary contaminants in the off-source area are metals and semivolatile organic compounds (SVOCs) in tidal channel sediment, and metals in wetland soil. Metals of concern in sediment consist of arsenic and chromium; and the metals of greatest concern in soil include aluminum, arsenic, chromium, and manganese. Other metals are present in sediment and soil but in lower concentrations and generally below levels of concern to human health and the environment. The SVOCs of primary concern in sediment consist of phenol, 4-methylphenol, fluoranthene and pyrene. Concentrations of concern are contained in **Table 1.**

---

[5] U.S. Environmental Protection Agency. Reference Area Performance Standards for Puget Sound. Puget Sound Estuary Program. EPA/910/9-91/041. September, 1991.

[6] Washington State Department of Ecology. Natural Background Soil Metals Concentrations in Washington State. Toxics Cleanup Program. Publication #94-115. October 1994.

Table 1 - Off-source Contaminants of Concern

Contaminant	Concentrations (mg/kg)
Sediments	
Arsenic	8.8 - 94.4
Chromium	24.9 - 300
Phenol	0.7 - 1.4
4-methylphenol	0.1 - 3.0
Fluoranthene	0.1 - 8.1
Pyrene	0.1 - 4.1
Soil	
Aluminum	2,640 - 33,800
Arsenic	3.7 - 47.3
Chromium	18 - 174
Manganese	146 - 3,620

The concentrations of SVOCs and metals in tidal channel sediment are generally highest south and west of the landfill. Concentrations of metals in wetland soil are highest in the areas surrounding most of the leachate seeps adjacent to the landfill berm.

6.0 SUMMARY OF SITE RISK

6.1 Overview of Comprehensive Baseline Risk Assessment for the Off-Source Area

The 1997 Comprehensive Baseline Risk Assessment (CBRA) was conducted to delineate and quantify potential current and future risks to human health and the environment in the off-source area of the Tulalip Landfill Superfund site. An earlier, separate, streamlined risk assessment, Final Tulalip Landfill Risk Assessment for Interim Remedial Action, August 1995, evaluated potential risks from the landfill source area. The CBRA was conducted assuming that the interim remedy, a cap over the landfill, as described in the interim 1996 ROD, was in place and fully functioning. The landfill cap is anticipated to eliminate leachate generation and discharge from the landfill within a few years following its completion, and thereby reduce contaminant loadings to the off-source area. The CBRA presents the results of each step in the risk assessment process including contaminant identification and screening, exposure assessment, toxicity assessment, risk characterization, and a discussion of uncertainties. A brief summary of each step is presented below.

6.2 Screening for Contaminants of Potential Concern

Contaminants identified at the site in various off-source media were evaluated for their potential to cause adverse impacts to humans and the environment. The media evaluated in the contaminant screening portion of the human health risk assessment included purged clams, fish fillets, and surface soil/sediment. The media evaluated in the contaminant screening portion of the ecological risk assessment included unpurged clams, whole-body fish tissue, small mammals, surface and subsurface soil, and surface and subsurface sediment.

Several criteria were used to screen off-source contaminants including frequency of detection, the elimination of contaminants considered essential nutrients, and comparison of site concentrations to risk-based concentrations. Contaminants that were detected at least once in a given medium associated with human health or ecological exposure pathways were retained as potential human health or ecological contaminants of potential concern (COPCs) for that medium. Contaminants that were considered essential nutrients (calcium, iron, magnesium, potassium, and sodium) and not clearly associated with quantifiable human or environmental toxicity were eliminated from further consideration.

All contaminants retained through the above screening steps that were detected in media associated with ecological exposure pathways of concern were retained as ecological COPCs. An additional risk-based screening step was conducted to determine human health COPCs. All contaminants retained through the above screening steps that were detected in media associated with human health exposure pathways of concern were compared to human health default risk-based concentrations (RBCs). These RBCs were based on cancer risks of no greater than one in a million and noncarcinogenic hazard quotients not to exceed 0.1.

EPA Region 3 human health risk-based concentrations tables were used to develop the RBCs, with the following three modifications. The residential scenario values were adjusted by integrating child and 30-year adult exposure for soil and sediment. The seafood ingestion values were adjusted by applying the Tulalip Tribes' ingestion rates for purged clam tissue. The adult consumption scenario was adjusted to account for Region 10 site-specific ingestion rates for whole-body sculpin tissue. Contaminants with maximum detected concentrations below RBCs were eliminated from further consideration in the human health evaluation, while contaminants detected at maximum concentrations above RBCs were retained as human health COPCs. If no RBC was available for a given contaminant, that contaminant was retained as a human health COPC. Since the ecological evaluation was based on a preponderance of evidence approach, which considered a broader spectrum of receptors and effects than is easily represented by a single set of risk-based screening criteria, a risk-based comparison was not conducted to determine ecological COPCs.

Contaminants selected as human health and ecological COPCs are presented in **Tables A-2 and Table A-3**, respectively. In total, 23 contaminants were identified as COPCs in at least one of the three media considered for human health (i.e., surface soil and sediment, fish, and shellfish). Eighty-one (81) non-nutrient contaminants were identified in the ecological COPCs screening process.

6.3 Exposure Assessment

The objectives of the exposure assessment were to identify the appropriate exposure scenarios to be used in the risk assessment based on current and predicted future land uses, identify likely pathways of exposure and media contaminated with COPCs, and calculate daily intakes of COPCs via the identified exposure pathways.

Current human use of the off-source area is fishing and hunting. Since the off-source area has been placed in a "conservation" use category by the Tribes, and no development may occur in this area with the exception of utility crossings, the most likely future land use of the off-source area was assumed to be recreational, including fishing and hunting.

Potential media of concern for human health exposure are surface soil and sediment, fish, and shellfish. Air, surface water, leachate, and groundwater were not considered to be media of concern. Air was not considered a medium of concern because the off-source area consists of tidally influenced wetlands with continually saturated soil/sediment which prevents significant fugitive dust emissions. Also, since volatile organics were not detected at high concentrations in the off-source area, vapor emissions were deemed not to be a significant contributor to exposure. Surface water is not a medium of concern for the off-source area based on the generally low levels of contaminants detected, and because the landfill cap is expected to eliminate transfer of contaminants of potential concern from the source to surface water. Leachate is not a medium of concern for the off-source area because leachate is expected to be eliminated by the source area interim containment remedy. Groundwater is not a medium of concern for the off-source area because it is not hydraulically connected to aquifers used for drinking water in the vicinity of the site, and because the interim containment remedy is expected to eliminate the discharge of contaminated groundwater to surface water by way of leachate seeps.

Likely human exposure scenarios are consumption of fish and shellfish, incidental ingestion of surface soil and sediment, and dermal contact with surface soil and sediment. Recreational activities including hunting, hiking, and fishing were identified as ways for adults to ingest or contact surface soils and sediments. Subsistence consumption of fish and shellfish was considered for adults and children. Risks related to recreational fishing and shellfish gathering were considered as part of the subsistence scenario.

Average and reasonable maximum exposures were considered for each exposure pathway. The reasonable maximum exposure is defined as the highest exposure that is reasonably expected to occur at a site. RME exposure assumptions included the use of the upper 95th percentile or maximum (whichever was lower) concentrations of constituents in exposure media, a 6-year exposure period for child scenarios and a 64-year exposure period for adult scenarios, and assuming that 39 percent of bottomfish and 79 percent of shellfish in the diet came from the off-source area.

Because the Tulalip site is located on tribal lands, and because some tribal members tend to consume subsistence levels of fish and shellfish, a tribal subsistence scenario was chosen to represent the reasonable maximum exposure at the site. A recent study of fish consumption habits of the Tulalip tribal members[7] revealed that the tribal members tend to consume a significantly larger amount of fish and shellfish than members of the general population. For example, the mean level of bottom fish consumption for the Tribes was reported to be 2.31 grams/day and for shellfish was 25.3 grams/day, for a total of 27.6 grams/day. The mean value for consumption of all fish and shellfish

---

[7] Toy, K.A., N.L. Polissar, S. Liao, and G.D. Gawne-Mittelstaedt. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region. Seattle, Washington. October 1996.

representative of the general population is 20.1 grams/day. The upper 95th percentile consumption rates reported for tribal members were 13.02 and 128 grams/day for bottom fish and shellfish, respectively, for a total of 141 grams/day. In contrast, the upper 95th percentile consumption rate of all fish and shellfish representative of the general population is 63 grams/day. Based on these values, it is clear that any remedial decisions based on a tribal subsistence fish consumption scenario will also be protective of individuals who consume recreational amounts of fish and shellfish.

Terrestrial ecological receptors included the soil-dwelling community, small mammals, and raptors. Aquatic ecological receptors included the benthic invertebrate community, fish, and fish-eating birds. Ecological receptors were evaluated based on specific organisms including soil microbes, soil invertebrates, plants, rodents, northern harriers, clams, mussels, amphipods, Pacific staghorn sculpin, and great blue herons. These receptors were assumed to be exposed to contaminants in the off-source area via direct contact with soil and sediment, indirect consumption of soil and sediment, and through ingestion along the food chain.

6.4 Toxicity Assessment

Risks to human and ecological receptors were measured based on several criteria. Human health was evaluated with respect to both cancer and noncancer risks. Cancer risks are expressed as an individual's chance (e.g., one in a million, or 1×10^{-6}) of developing cancer from off-source exposure to a given contaminant (e.g., arsenic) or environmental medium (e.g., soil) over an average lifetime (i.e., 70 years). Noncancer risks are expressed as a ratio of the amount of a contaminant in off-source media to which a person is exposed compared to the amount of that contaminant associated with a minimal likelihood of causing adverse health effects (i.e., a toxicity value). These ratios are referred to as hazard quotients. Human health toxicity values were taken from the Integrated Risk Information System (IRIS) database and Health Effects Assessment Summary Tables (HEAST).

Risks to ecological receptors were evaluated using both toxicity criteria and reference concentrations. Toxicity values represent levels of contaminants above which adverse effects are expected to occur; and reference concentrations represent concentrations measured in similar environmental media or organisms (e.g., clams) that were not influenced by landfill contaminants. Due to the lack of acceptable site-specific background concentrations, reference concentrations were based on alternate studies and literature values representing areas that were not located in the direct vicinity of the off-source area. Hazard quotients were used to represent the ratio of the amount of a given contaminant to which that receptor is exposed compared to the reference or toxicity value associated with that contaminant (e.g., mercury) and a given receptor (e.g., great blue heron).

6.5 Risk Characterization

Risks to humans were evaluated for both cancer and noncancer effects. Cancer risks are expressed as an individual's chance of developing cancer from exposure to a given contaminant or environmental medium in the off-source area. EPA considers excess cancer risks in the range of 10^{-4} to 10^{-6} to be generally acceptable. When excess cancer risks exceed 10^{-4}, EPA will consider the need for a cleanup action. EPA has further clarified the extent of the acceptable risk range by stating that the upper boundary is not a discrete line at 1×10^{-4}. Risks slightly greater than 1×10^{-4} may be considered to be acceptable if justified based on site-specific conditions, including any uncertainties regarding the nature and extent of contamination and associated risks[8]. Noncancer risks are expressed as hazard quotients. Hazard quotients are ratios of the actual dose of a particular contaminant from relevant off-source media compared to a reference dose for that contaminant. Hazard quotients greater than 1.0 indicates a potential for noncarcingenic health effects from site contaminates. As with hazard quotients used to evaluate human health effects, ecological hazard quotients greater than 1.0 indicate a potential for concern.

The risks presented below were calculated based on total concentrations of contaminants in the off-source area (i.e., including contamination from all potential sources), and conservative assumptions about potential exposure to off-source media. Where potentially unacceptable human health or ecological risks were identified, the assumptions used to estimate those risks are further examined in the following section of this document in order to assess uncertainties associated with the predicted risk levels. This approach is consistent with EPA policy on risk management decision making and general remedy selection principles as described in the National Contingency Plan.

Tables A-4 and A-5 identify the calculated total carcinogenic and noncarcinogenic risks for human health for the

[8] U.S. Environmental Protection Agency. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30. April 22, 1991.

reasonable maximum exposure (RME) and the average exposure (CTE or central tendency exposure) scenarios. Human health risks were driven by consumption of arsenic-contaminated shellfish collected from the off-source area. For the reasonable maximum exposure scenario, adult cancer risk from off-source shellfish consumption was conservatively estimated as 9×10^{-4} or nine in ten thousand, and the adult noncancer hazard index from off-source shellfish consumption was conservatively estimated to be 3.1. Arsenic was the largest single contributor to risks from shellfish consumption, contributing 94 percent of cancer risk and 66 percent of noncancer hazard index. Cancer risk to children consuming large amounts of seafood (the reasonable maximum exposure) was calculated to be over an order of magnitude lower than for the adults, and fell within EPA's acceptable risk range. The corresponding hazard index was estimated to be 1.0. For the average exposed subsistence individual (one who consumes less fish and shellfish than a reasonable maximum), adult and child carcinogenic risks fell within the acceptable risk range, and hazard indices fell below 1.0. All cancer risks (the reasonable maximum and the average) from incidental ingestion of off-source surface soil/sediment, dermal contact with off-source surface soil/sediment, and consumption of fish fell within or below EPA's cancer risk management range. Similarly, all noncancer hazard quotients for these exposure pathways were less than 1.0.

Risks were evaluated for off-source aquatic organisms including fish-eating birds (great blue heron), fish (Pacific staghorn sculpin), and benthic invertebrates (clams, amphipods, and mussels). The potential for adverse impacts to the population size of the fish-eating birds was estimated to be minimal, with no hazard quotients greater than 1.0. The potential for adverse impacts to the population size of the fish community was estimated to be low, with only PCB Aroclor 1254 and copper having hazard quotients minimally greater than 1.0. Some potential for adverse impacts to the abundance and diversity of benthic invertebrates was found. The range of risks was slightly greater than a hazard quotient of 1.0, and much less than 10. Contaminants that contributed to the estimated risks were primarily semivolatile organics (4-methylphenol and phenol, fluoranthene, and pyrene), as well as two inorganics (arsenic and chromium).

Risks were also evaluated for off-source terrestrial organisms including raptors (northern harrier), small mammals (shrew, vole, and deer mouse), and soil-dwelling organisms (plants, earthworms, and soil microorganisms). The potential for adverse impacts to the population size of the raptor community was estimated to be minimal, with no relevant hazard quotients greater than 1.0. The potential for adverse impacts to the population size of small mammals was estimated to be low, with only mercury and selenium having hazard quotients minimally greater than 1.0. Some potential for adverse impacts to the abundance and diversity of soil-dwelling organisms was found. Hazard quotients were elevated only marginally (i.e., by less than an order of magnitude) for two organic contaminants, acenaphthene and fluorene; but were substantially elevated (i.e., by more than an order of magnitude), for a few inorganic contaminants including aluminum, chromium, and vanadium.

6.6 Uncertainties

The CBRA includes detailed discussions of the uncertainties associated with the estimation of exposures and risks for human health and ecological organisms. Uncertainties related to general site conditions, sampling and analysis, and fate and transport parameters are also discussed in the CBRA.

6.6.1 Key Uncertainties Associated with Calculated Risks for Human Health

For human health, the results of the CBRA indicate that only one exposure scenario (subsistence level ingestion of shellfish from the off-source area) exceeds the acceptable risk range for carcinogens and the hazard index for noncarcinogens. Other pathways (incidental soil/sediment ingestion and fish ingestion), using conservative estimates, were not determined to present unacceptable risks. The key uncertainties associated with the calculated risks from the shellfish ingestion scenario are as follows:

- <u>Overestimation of fish and shellfish consumption and availability</u> – Risk assessments were based on an adult subsistence level of consumption and assumed 100 percent of this subsistence diet was collected from the off-source area. This scenario is unlikely.

- <u>Use of a single shellfish species to represent all shellfish consumed from the off-source area</u> – The use of clams to represent all shellfish species consumed from the off-source area may have resulted in further overestimation of risks. Clams, which reside in sediment, are likely to contain higher concentrations of contaminants than other shellfish present in the off-source area. A variety of other edible shellfish (including crabs, mussels and soft-shell clams) are present in the off-source area and likely have significantly lower contaminant concentrations.

- <u>Percentage of inorganic arsenic in seafood</u> – The CBRA assumed that 10 percent of arsenic contained within edible fish and shellfish was of the toxic, inorganic form. Another study[9] indicates that actual inorganic arsenic concentrations likely range from 0 to 2.9 percent. The assumption of 10 percent inorganic arsenic in shellfish could contribute to a risk overestimation factor of as much as 3 times the actual risk present in the off-source area.

- Regional sediment arsenic levels similar to off-source area arsenic levels – An attempt to gather site-specific background concentrations was unsuccessful during the remedial investigation. As a result, regional background arsenic concentrations were used as a comparison. The results of this comparison demonstrate that although tissue arsenic concentrations of clams grown in off-source sediment tend to be slightly higher than those measured in other Puget Sound locations, they are similar to ranges found within regional shellfish tissue background concentrations.

While risk estimates in general are affected by many uncertainties which could either increase or decrease estimated risk, EPA notes that the key uncertainties associated with the shellfish ingestion scenario when considered cumulatively have the effect of lowering estimated risks by as much as a full order of magnitude.

6.6.2 Key Uncertainties Associated with the Calculated Risks to Soil Organisms

The primary uncertainty associated with the ecological risk estimates is the chemical form or bioavailability of the contaminants. In the CBRA, it was assumed that contaminant concentrations were 100% bioavailable. This is highly doubtful, particularly for inorganics, since contaminants in the ambient environment are quite frequently bound as complexes that reduce their overall bioavailability. Therefore, risks are most likely overestimated.

A secondary set of uncertainties relates to the toxicity criteria used. For the soil evaluation, toxicity criteria were gathered from the Oak Ridge National Laboratory[10] database, which

---

[9] Chew, C.M. Toxicity and Exposure Concerns Related to Arsenic in Seafood: An Arsenic Literature Review of Risk assessments. Prepared for Region X EPA Risk Evaluation Unit. March, 1996.

[10] Oak Ridge National Laboratory. Screening Benchmarks for Ecological Risk Assessment. Version 1.5. Prepared by Environmental Sciences and Health Sciences Research Divisions, Oak Ridge Tennessee, for U.S. Department of Energy, Washington, DC. 1996.

was developed primarily for screening purposes. The effects associated with the toxicity levels include decreased growth and decreased activity, both of which may or may not be indicative of serious deleterious effects to species populations and/or the overall ecosystem at the site (i.e., these are fairly conservative values based on the not-so-severe nature of effects used). Conversely, these toxicity criteria are based on a 20% observed reduction in effects, not a "no effects" level. Therefore, it is possible that they may not be conservative enough.

Finally, a comparison of regional background concentrations of the inorganic contaminants[11] does not indicate greatly elevated levels in off-source soil. Based on this comparison, it is likely that a significant portion of risks to the soil-dwelling community from inorganic contaminants may be attributable to natural background levels.

6.7 Assessment of Site Risk

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action for the on-source and off-source areas as selected in this ROD, may present an imminent or substantial endangerment to human health, welfare, or the environment.

7.0 OFF-SOURCE AREA REMEDIAL ACTION OBJECTIVES

7.1 Off-source Areas of Concern

The CBRA identified consumption of fish and shellfish as the primary pathway associated with potential risks to humans. A tribal subsistence scenario was assumed in the CBRA and used to determine average and reasonable maximum exposure limits (RME) based on the possibility of some tribal members consuming subsistence levels of the fish and shellfish contained in the off-source area. Only the RME exposure scenario exceeded the acceptable risk range. Potential risks to adults who consume average subsistence levels and to children who consume subsistence levels of seafood were below levels of concern. The primary contaminant of concern related to human consumption of fish/shellfish was arsenic. Other metals, pesticides, and PCBs also contributed to these risks.

A background evaluation was conducted which compared

---

[11] Washington State Department of Ecology. Natural Background Soil Metals Concentrations in Washington State. Toxics Cleanup Program. Publication #94-115. October 1994.

concentrations of sediment contaminants in the off-source area with existing regional soil and sediment background concentrations. Contaminants found to exceed background concentrations include aluminum, arsenic, chromium, and manganese. Most of the exceedances were found to be marginally above the background concentrations except for arsenic and, to a lesser degree, chromium. It is important to note that even regional sediment background concentrations of arsenic indicate potential risks to human health, and regional soil background concentrations of chromium indicate potential risks to terrestrial ecological receptors.

Off-source areas with soil and sediment background exceedance ratios greater than or equal to 1.20 (20 percent above background) were evaluated for potential remedial action. Focusing on areas with metal concentrations more than 20 percent over background would maximize cleanup of areas of the greatest potential harm to human health and the environment.

Although fish tissue data suggest the potential for human health risks from ingestion of pesticides and PCBs in fish, these compounds were detected in few off-source sediment locations and, where found, they were detected at low concentrations. Therefore, EPA has determined that remediation of sediment for pesticides and PCBs is not warranted. It is possible that because fish may also forage off site, they may have accumulated some of these contaminants from off-site locations.

Off-source sediment exceeds Washington State Sediment Management Standards (SMS) Sediment Quality Standard (SQS) and Cleanup Screening Level (CSL) concentrations for some SVOCs and metals. Phenol generally exceeded only SQS and not CSL concentrations. Since phenol was generally detected below SQS and since it readily degrades and attenuates in the aquatic environment, it was not considered for cleanup. Sediment CSL exceedances were associated with 4-methylphenol, fluoranthene, pyrene, chromium and arsenic. The off-source areas with CSL exceedances for these contaminants were considered in determining cleanup areas based on potential ecological impacts.

Based on the conclusions in the risk assessment, **Table 2** shows which stations are associated with areas that did undergo remedial alternative evaluation and the likely receptors and contaminants.

Table 2 - Remedial Alternative Evaluation Areas

Sample Station	Receptor/Pathway	Contaminant	Criteria Exceeded
Sediment			
SG-06	Shellfish Consumption	Arsenic	Background
SG-10	Benthos Contact	4-Methylphenol	CLS
SG-11	Benthos Contact	4-Methylphenol	CLS
SG-13	Benthos Contact	Fluoranthene, Pyrene	CLS
SG-15	Shellfish Consumption Benthos Contact	Arsenic	Background, CLS
SG-18	Shellfish Consumption	Arsenic	Background
SG-20	Benthos Contact	4-Methylphenol	CLS
SG-21	Benthos Contact	4-Methylphenol	CLS
SG-24	Shellfish Consumption	Arsenic	Background
SG-25	Shellfish Consumption	Arsenic	Background
SG-32	Benthos Contact	4-Methylphenol	CLS
Soil			
Seep 1	Terrestrial Ecological	Chromium, Arsenic	Background
Seep 2	Terrestrial Ecological	Chromium, Arsenic	Background
Seep 3	Terrestrial Ecological	Chromium	Background
Seep 4	Terrestrial Ecological	Chromium	Background
Seep 5	Terrestrial Ecological	Chromium, Arsenic	Background
Seep 6	Terrestrial Ecological	Chromium, Arsenic	Background
Seep 7	Terrestrial Ecological	Chromium, Arsenic	Background
Seep 8	Terrestrial Ecological	Chromium	Background

7.2 Remedial Action Objectives

Remedial action objectives (RAOs) are medium-specific or operable-unit-specific goals to protect human health and the environment. RAOs specify the exposure routes and receptors, contaminants of concern, and an environmental or human health remediation objective.

Elevated site risks are associated with human ingestion of shellfish living in sediment around the landfill. Ecological risks are associated with sediment in some tidal channels around the landfill and with wetland soil adjacent to most of the leachate seeps on the landfill berm. Since even in their current state the wetlands surrounding the landfill play an important ecological role in the Snohomish River delta and Puget Sound, goals established to address chemical contaminants must be balanced against physical impacts to the wetlands associated with potential remedial actions in the off-source area. An executive order requires that federal agencies avoid adversely impacting wetlands wherever possible, minimize wetland destruction, and preserve the value of wetlands.

The RAOs for the Tulalip Landfill off-source area are:

- Minimize human consumption of fish/shellfish which contain contaminants that result in an elevated potential risk.

- Minimize potential for arsenic-contaminated soil surrounding the leachate seeps from acting as a continuing source of arsenic in the off-source sediment.

- Minimize potential for benthic organisms to contact sediment which exceeds CSLs without physically destroying wetland habitats.

- Minimize potential for terrestrial ecological receptors to contact soil containing arsenic, manganese, and chromium at concentrations significantly greater than background concentrations.

- Minimize physical impacts to and loss of off-source wetlands.

7.3 Applicable, Relevant and Appropriate Requirements (ARARs)

The Washington Sediment Management Standards (WA 173-204) are ARARs for the off-source remedial action because they establish numerical values for chemical constituents in sediments, and Executive Order 11990 is a to-be-considered (TBC)requirement because it requires that federal agencies avoid adversely impacting wetlands wherever possible and preserve the value of wetlands.

Washington Sediment Management Standards (WAC 173-204) are relevant and appropriate requirements to the off-source remedial action. The Washington Sediment Management Standards establish numerical values for chemical constituents in sediments. These standards are not legally applicable, because the site is located on tribal lands where state requirements are not enforceable. However, the standards are relevant and appropriate because their purpose is to provide standards for determining acceptable levels of contaminants in sediments. The selected remedial action for the off-source area complies with these standards because, following source control, natural recovery will reduce the concentrations of organics and inorganics.

Executive Order 11990 ("Protection of Wetlands"), as implemented by 40 C.F.R. Part 6, Appendix A is a TBC for the off-source remedial action. Within and adjacent to wetlands, Executive Order 11990 directs actions to be performed so as to minimize the destruction, loss, or degradation of wetlands. The off-source area of the site consists of ecologically productive wetlands, and Executive Order 11990 is, therefore, to be considered in selecting a remedy for the off-source area that results in minimal destruction of, or impact to, these valuable wetlands. Since the Tulalip Landfill is located on tribal property, state regulatory requirements do not necessarily apply to work performed in this location. However, compliance with the federal regulations and the substantive portions of state regulations is prudent to protect the environment.

8.0 DESCRIPTION OF ALTERNATIVES FOR THE OFF-SOURCE AREA

8.1 Alternative 1: No Action

The no-action option involves no active remedial efforts and would not reduce the mobility, toxicity, or volume of the contamination contained in the off-source area. Following the implementation of the interim remedial action landfill cap, the off-source area would remain in its existing condition. No effort would be made to restrict access to the off-source area and any potential for human and ecological exposure to contamination would remain.

Existing contamination would remain in place. Following source control, organic contaminants would be left to degrade through natural processes such as dilution, dispersion, and biodegradation. Metals exceedances in the wetlands could be expected to recover over time through natural recovery (sedimentation) since the off-source area is generally depositional. Any activities occurring on or near the contaminant areas would be allowed to continue without restriction. Periodic monitoring, which is already required by the interim remedial action ROD, could be used to ensure contaminant levels in the off-source area will not pose a threat to human health or the environment.

The no-action option is typically used as a baseline comparison for the evaluation of additional remedial technologies. No action may be appropriate when risks posed by contamination are considered insignificant. No action may also be viable when alternative remedial technologies are anticipated to cause a disproportionate amount of environmental damage in comparison to the risks posed by the presence of contamination.

8.2 Alternative 2: Institutional Controls/Natural Recovery

This alternative consists of maintaining existing signs, and as necessary, posting new signs along the perimeter of the sloughs and landfill warning of the potential risk from harvesting and eating fish and shellfish. Signs would be located approximately every 300-600 feet along Steamboat Slough and Ebey Slough. Additional signage as necessary would be posted by the Tribes or a potentially responsible party, in and around the off-source area by the use of manual labor, boats, and rafts.

Following source control, natural recovery would reduce the concentrations of organics and inorganics. The organics present are predominantly phenols and phenolic compounds. These materials are water soluble and highly biodegradable. The organic concentrations are relatively low in concentration and would degrade over time. The metals in the sediments are expected to recover to background concentrations over time through the deposition of clean sediment on their surface during periodic flooding events in the sloughs.

Inspection and maintenance of the signs would be performed by the Tulalip Tribes to ensure that they were still in place and readable. The Tribes would also be responsible for enforcement of this institutional control. Periodic monitoring of the impacted sediment and seep soil is already required by the interim remedial action ROD. Monitoring would ensure the contaminants were attenuating and not migrating or increasing in concentrations.

8.3 Alternative 3: Capping

This alternative would consist of covering the impacted sediment areas shown in **Figure 6** with a nominal 1 foot of clean fine-grained fill. Contaminated seep soil would be capped with 2 feet of clean fill after removing the top 2 feet of contaminated soil. Removal of the top 2 feet would be performed to minimize the erosion potential of the cap material. Removal to cleanup criteria is not considered feasible since the soil is most likely contaminated from leachate and is anticipated to extend to considerable depth.

Table 3 shows the estimated fill volumes that would be required to cap the tidal channel sediments. **Table 4** shows the estimated cut and fill volumes for capping the seep area soil. To provide access to these areas, a perimeter road would need to be constructed around the base of the landfill to provide access to the areas requiring remediation as the landfill berm cover has not been designed to withstand equipment traffic. Floating equipment (e.g., barges) would not be practical due to the low frequency with which the wetlands are submerged.

Table 3 - Sediment Capping Areas and Estimated Volumes

Station	Length (ft)	Width (ft)	Fill Depth (ft)	Fill Volume (C.Y.)
SG-06	250	30	1	278
SG-10 &11	400	20	1	296
SG-13	200	20	1	148
SG-15	100	30	1	111
SG-18	200	20	1	148
SG-20 &21	1,200	30	1	1,333
SG-24	400	30	1	444
SG-25	200	10	1	74
SG-32	150	50	1	278
Total				3,110

Table 4 - Estimated Seep Area Soil Cut and Fill Volumes

Seep Area No.	Length (ft)	Width (ft)	Removal Depth (ft)	Remove/Fill Volume (C.Y.)
1	140	90	2	933
2	200	150	2	2,222
3	70	60	2	311
4	40	40	2	119
5	120	60	2	533
6	200	180	2	2,667
7	200	170	2	2,519
8	30	30	2	67
Total				9,371

The access road required for construction would need to be approximately 20 feet wide and 8,200 feet long. To construct this road in the soft soil, it is assumed that an equivalent thickness of up to 3 feet of granular fill would be needed. It may also be necessary to lay geotextile material prior to road construction to provide additional support for the road base.

Once the road was constructed, the cap material would be off-loaded from mix trucks and discharged into the inlet of a mud pump. Rubber pipelines would be placed manually over swamp mats or similar devices from the slurry area out into the wetland, where the clean mud slurry would be placed over the existing contaminated sediments. Equipment would need to be moved and relocated to eight different locations to reach the contaminated areas. Final leveling of the sediment would be performed manually.

Silt fences and oil booms would be installed downstream of the placement area in the tidal channels and sloughs to trap sediment and minimize sediment loss and contain any floating organic contaminants which may be released during remediation.

Seep area soil would be excavated to a depth of 2 feet. The soil would be loaded into trucks for proper off-site disposal at a landfill. Clean soil would be brought to the site via dump trucks and used to fill the excavation areas.

8.4 Alternative 4: Removal and Off-site Disposal

This alternative consists of removing the contaminated sediment from the tidal channels. To minimize the release of sediments to the wetlands, a vortex dredging pump would be used to remove the contaminated sediment. The dredging pump would need to be supported on the end of a tracked excavator or small crane. The sediment dredging areas and volumes are listed in **Table 5**. It was assumed that a 1-foot dredge depth would be adequate to remove the impacted sediment.

Table 5 - Sediment Dredging Areas and Estimated Volumes

Station	Length (ft)	Width (ft)	Fill Depth (ft)	Fill Volume (C.Y.)
SG-06	250	30	1	278
SG-10 &11	400	20	1	296
SG-13	200	20	1	148
SG-15	100	30	1	111
SG-18	200	20	1	148
SG-20 &21	1,200	30	1	1,333
SG-24	400	30	1	444
SG-25	200	10	1	74
SG-32	150	50	1	278
Total				3,110

Seep area soil would be removed to a depth of 2 feet and capped with clean soil as in Alternative 3. Removal to cleanup criteria is not considered feasible since the soil is most likely contaminated from leachate and is anticipated to extend to considerable depth.

A road system would be constructed to provide access to the seep area soil as well as the tidal channel sediment. Roads would need to be constructed next to the tidal channels to provide access for the dredging equipment. The roads would be constructed of 3 feet of import granular fill. The perimeter road would be 20 feet wide and the tidal channel access roads would be approximately 10 feet wide. Roads would need to be constructed out to each of the nine different areas. The total length of road that would need to be constructed is approximately 8,200 feet of perimeter road and 3,600 feet of access road along the tidal channels.

The contaminated sediment would be dredged from the estuary where it would be pumped to a pond constructed at the foot of the landfill. Booster pumps would be required to pump the sediment to the pond. The pond would be lined with a geotextile and have a capacity of approximately 1,200,000 gallons. The pond would be approximately 200 feet wide by 200 feet long by 4 feet deep. This pond size would allow for an equal quantity of water as sediment to be dredged (i.e., 1:1 sediment to water ratio).

The dredged sediment would be allowed to dewater and then be decanted. The remaining soft sediment would need to be stabilized with flyash to eliminate separable water. The stabilized material would then be loaded into trucks for proper disposal. It is anticipated that approximately 50 percent by weight of flyash to sediment would be needed to absorb the entrained water in the sediment.

This alternative would result in the dredging of approximately 3,100 cubic yards of sediment. Stabilization would create a total of 4,700 cubic yards, which may require off-site disposal. It is estimated that approximately 600,000 gallons of water would require treatment as a result of sediment dewatering. The water would be filtered and passed through a carbon treatment system to remove any dissolved organic compounds. Treated water would be discharged back into the slough.

Seep area soil capping would require removal of approximately 9,400 cubic yards of soil. The remaining pits would be capped with an equal quantity of clean fill.

Monitoring would be required in this alternative since contaminated soil would be left in place in the seep areas.

9.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE OFF-SOURCE AREA

To evaluate and select a preferred alternative for the Tulalip Landfill Superfund site off-source area, EPA used the criteria below. Comments on the proposed plan were used to evaluate the preferred alternative regarding the last two criteria: tribal acceptance and community acceptance.

1) ***Overall protection of human health and the environment*** *addresses whether a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.*

2) ***Compliance with applicable or relevant and appropriate requirements (ARARs)*** *addresses whether a remedy will meet all of the ARARs of other Federal and State environmental laws and/or justifies a waiver.*

3) ***Long-term effectiveness and permanence*** *refers to expected residual risk and the ability of the remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.*

4) ***Reduction of toxicity, mobility, or volume through treatment*** *is the anticipated performance of the treatment technologies a remedy may employ.*

5) ***Short-term effectiveness*** *addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until cleanup goals are achieved.*

6) ***Implementability*** *is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.*

7) ***Cost*** *includes estimated capital and O&M cost, as well as*

present-worth cost.

8) ***Tribal acceptance*** *includes consideration of the Tribes' comments on the Proposed Plan and whether they support EPA's preferred alternative.*

9) ***Community acceptance*** *summarizes the public's general response to the alternatives described in the Proposed Plan and RI/FS Report.*

9.1 Overall Protection of Human Health and the Environment

9.1.1 Alternative 1: No-Action

The no-action alternative is not protective of human health and the environment. Fishing activities and the collection of shellfish would be allowed to continue without restriction. Potential impacts to human health may occur through the ingestion of fish and shellfish containing elevated levels of arsenic within the off-source area. Environmental impacts may occur through sediment benthos and soil-dwelling organism exposure to elevated levels of organics and metals. Although contaminant reduction will occur through source control and natural attenuation processes over time, the no-action alternative does not actively reduce the immediate human health risks posed by elevated contaminant levels in the off-source area.

9.1.2 Alternative 2: Institutional Controls

Alternative 2 provides protection of human health by warning potentially affected parties of the potential hazards presented by the off-source area. The warning of potentially affected parties is accomplished through the placement of signs in and around the perimeter of the off-source area. Similar to the no-action alternative, Alternative 2 does not actively reduce the risks posed by elevated contaminant levels in the off-source area.

Protection of the environment is limited to natural processes that can be expected to occur in the off-source area over time following source control. These processes may degrade the presence of organics through dilution, dispersion, and natural attenuation. Inorganic contaminants in sediment (such as arsenic) can be expected to decrease in concentration after source control due to sedimentation processes.

9.1.3 Alternative 3: Capping

Alternative 3 would provide protection of human health and the environment through the containment of contamination found in the off-source area. Potential risks to human health would be mitigated by lessening the potential for human consumption of contaminated seafood. Environmental risks would be reduced by isolating contaminants from exposure to benthic organisms and many local terrestrial wildlife species. Contaminant exposure to soil-dwelling organisms would be reduced if this alternative were implemented by providing them uncontaminated surface soil and sediment.

Implementation of this alternative could be expected to significantly damage the wetland areas that need to be traversed to place pipelines and equipment. Large volumes of fill for the access road, and swamp mats or similar devices for the pipelines, would need to be placed over the soft wetland soil. These actions would tend to destroy and damage plant and wildlife habitat.

9.1.4 Alternative 4: Removal

Alternative 4 provides protection of human health and the environment. The removal of potentially hazardous off-source contaminant areas would decrease the incremental risks from human consumption of impacted seafood and from environmental exposure to contamination within the off-source area. Seep soil and sediments exceeding cleanup goals would be removed and properly transported off site.

Significant damage to the wetlands could be expected to occur similar to Alternative 3 except to a larger degree. This is due to the need to construct additional access roads into the tidal channels to allow access for dredging equipment.

9.1.5 Comparison of Alternatives

As discussed above, Alternatives 2, 3, and 4 are protective of human health and the environment. Alternative 1 is not protective of human health because it would allow fishing and collection of shellfish from contaminated areas.

9.2 Compliance with ARARs

9.2.1 Alternative 1: No-Action

This alternative would comply with all ARARs, including, in the long-term following source control, the guidelines in the Washington State Sediment Management Standards (SMS).

9.2.2 Alternative 2: Institutional Controls

This alternative would comply with Executive Order 11990 since damage to the wetlands and impact to water quality would be minimal. Compliance with the SMS in the long term would be met following source control and natural attenuation.

9.2.3 Alternative 3: Capping

Filling portions of the wetlands with the access road and cap material does not meet the intent of Executive Order 11990 "Protection of Wetlands," which discourages filling or damaging wetlands.

Capping would meet the requirements of the SMS regarding isolating the contaminants of concern from the environment.

9.2.4 Alternative 4: Removal

This alternative does not meet ARARs. Executive Order 11990 "Protection of Wetlands" discourages damaging and destruction of wetlands. Construction of access roads into the wetland to make access for dredging equipment would cause significant damage which, over time, may disappear.

This alternative would remove the contaminants above SMS guidelines and would thereby meet the requirements of this ARAR.

Separable water from sediment dewatering would be treated to meet ambient water quality criteria (AWQC) and Clean Water Act (CWA) discharge concentrations in addition to other likely National Pollutant Discharge Elimination System (NPDES) requirements regarding dissolved oxygen, oil and grease, and turbidity. Treated water would be discharged back into the sloughs.

9.2.5 Comparison of Alternatives

Implementing a remedy that requires intrusive work in the wetlands is anticipated to cause damage to the wetlands. An alternative such as capping would probably have the least impact. Alternatives 3 and 4, which require heavy equipment to move into the wetlands, would cause significant damage. These intrusive types of alternatives would not meet the intent of ARARs designed to protect these sensitive areas. Executive Order 11990[12] requires that federal agencies avoid adversely impacting wetlands wherever possible, minimize wetlands destruction, and preserve the value of wetlands. Alternatives 1 and 2 would meet all of the requirements of ARARs.

---

[12] Protection of Wetlands, Executive Order 11990 (40CFR Part 6, Appendix A)

9.3 Long-Term Effectiveness and Permanence

9.3.1 Alternative 1: No-Action

The no-action alternative does not actively remove contaminated soil or sediments from the off-source area. The risks that remain following the "implementation" of this alternative are equivalent to the risks currently present in the off-source area, although eventually interim remedy source control and natural attenuation are expected to reduce risks to background levels.

The no-action alternative does not provide any type of warning to the potentially affected users of the off-source area. These potentially affected parties include the members of the general public and the Tulalip Tribe members who utilize the off-source area for subsistence fishing and shellfish collection. Therefore, even though source control will minimize future releases of contaminants from the landfill, the long-term effectiveness and permanence of this remedy in protecting human health may be low because even regional background clam tissue and sediment concentrations lead to unacceptable potential risks for subsistence seafood consumers using the conservative assumptions of the Tulalip Landfill off-source area CBRA.

Long-term protectiveness of the environment would be considered to be moderately effective since natural attenuation is anticipated to reduce the contaminant concentrations over time.

9.3.2 Alternative 2: Institutional Controls

Alternative 2 does not actively remove contaminated soil or sediments from the off-source area. The magnitude of remaining risks following the implementation of this alternative is equivalent to the risks currently present in the off-source area, although following source control natural attenuation should reduce risks to background levels.

In comparison to Alternative 1, Alternative 2 exhibits an increased degree of long-term effectiveness due to the posting of signs, which can remain on site indefinitely. These signs can be expected to provide adequate warning to potentially affected parties of the possible hazards posed by the off-source area. Periodic inspection of the institutional controls put in place would ensure that the signs remain in visible locations and are free from overgrown vegetation, debris, etc.

Overall, this alternative provides a moderate degree of long-term protectiveness.

9.3.3 Alternative 3: Capping

Capping would generally have good long-term effectiveness. The long-term effectiveness and permanence of capping may be diminished by the possibility of the eventual deterioration of the capping system. This deterioration could be caused by natural factors such as local erosion (particularly in the tidal channels). Periodic inspections of the capping system would be necessary to ensure that the integrity of the cap remains uncompromised. Capping material may require augmentation or replacement should the original capping system become compromised. The magnitude of residual risks posed by contamination is not directly reduced by capping efforts, but instead the contamination is made inaccessible to potentially affected parties and wildlife. It is anticipated that natural processes could reduce organic contaminant concentrations after capping measures have been instituted.

9.3.4 Alternative 4: Removal

Alternative 4 provides good long-term effectiveness and permanence, provided that the extent of potentially hazardous contaminant areas has been adequately estimated. Assuming that a 1-foot dredge depth for sediment and a two-foot dredge depth for seep area soil would adequately remove the extent of contamination, the magnitude of residual risks is negligible. The dredging and removal of contamination is inherently permanent and is considered to be a reliable method for the reduction of on-site contamination.

The dredged sediment and seep soil areas would be covered with clean fill. Since these areas would be graded and compacted to an elevation similar to the surrounding grade, it is likely that the capped areas would remain intact for long periods.

9.3.5 Comparison of Alternatives

Alternative 1 provides moderate long-term effectiveness. Alternative 2 has moderate long-term effectiveness given adequate maintenance of controls by the Tribes and successful implementation of the interim action source control. Alternatives 3 and 4 are likely to have good long-term effectiveness although negative physical impacts to the wetlands would be long lasting.

9.4 Reduction in Toxicity, Mobility, and Volume Through Treatment

9.4.1 Alternative 1: No-Action

Alternative 1 does not actively treat, contain, or remove the contaminated soil or sediments found in the off-source area. As a result, the only reduction in toxicity or volume would occur through natural processes. Organic contaminants would be left to degrade through natural processes such as dilution, dispersion, and biodegradation. Inorganic contaminants are expected to be covered with clean sediments during flooding/depositional periods, thereby reducing their surface concentrations. This alternative does not satisfy the statutory preference for treatment as the principal method of risk reduction.

9.4.2 Alternative 2: Institutional Controls

Alternative 2 does not actively treat, contain, or remove the contaminated soil or sediments found in the off-source area. As a result, the only reduction in toxicity or volume would occur through natural processes. Organic contaminants would be left to degrade through natural processes such as dilution, dispersion, and biodegradation. Inorganic contaminants can be expected to be reduced in concentration through sedimentation processes over time. This alternative does not satisfy the statutory preference for treatment as the principal method of risk reduction.

9.4.3 Alternative 3: Capping

Alternative 3 does not actively treat or destroy contaminated soil and sediments and therefore does not offer any active reduction in toxicity or volume of contamination. Some reduction in organic contaminant concentrations may occur through natural processes following source control. Inorganic contaminants can be expected to remain in the same concentration in the subsurface environment over time. This alternative does not satisfy the statutory preference for treatment. Mobility of contamination is reduced in Alternative 3 by removing contaminated soil and covering contaminated sediments with a fine-grained material. This cap material will act to reduce the possibility of contamination being scoured from "hot spots" and carried away from the landfill by ebb tide flows in the off-source area tidal channels.

9.4.4 Alternative 4: Removal

Removal and off-site disposal does not result in any physical or chemical changes in the contaminants and does not therefore provide any reduction in the toxicity or volume of the contamination. Contaminant mobility is reduced due to the removal of soil and sediments from an uncontrolled environment and the disposal these contaminants within a well-confined and monitored landfill. Contaminant mobility is also reduced by the mixture of flyash with potentially contaminated sediments for the purposes of stabilization.

9.4.5 Comparison of Alternatives

None of the alternatives actively treat or destroy contaminated soil and sediments. Therefore they do not offer any active reduction in toxicity or volume of contamination through treatment.

9.5 Short-Term Effectiveness

9.5.1 Alternative 1: No-Action

The no-action alternative is not effective in the short term because the immediate risk to human health is not mitigated. However, no risks are posed to workers since there are no efforts required to implement this alternative. The no-action alternative is readily implementable and will not result in any negative environmental impacts, due to the lack of active remedial efforts.

9.5.2 Alternative 2: Institutional Controls

Alternative 2 provides good short-term effectiveness. The posting of signs should provide an immediate reduction of risk by informing potentially affected parties of possible risks posed by the off-source area. Minimal risks are posed to workers, the public, and the environment since there is little effort required to implement this alternative. Alternative 2 is readily implementable and will not result in any negative environmental impacts, due to the intrinsic lack of active remedial efforts.

9.5.3 Alternative 3: Capping

Capping is not effective in the short term. The greatest short-term risks posed by Alternative 3 arise from worker placement of pipelines and other work in the soft sediments. The potential of a worker getting stuck in the sediment is high due to the degree of manual labor required in this alternative. A lesser degree of risk also exists during the construction of the perimeter road. The use of heavy machinery in soft soils such as those present in the off-source area poses a legitimate risk to workers involved in the implementation of this alternative. Additional risks are presented by leaving potentially hazardous soil and sediments in place, and although containing these materials through capping processes acts to reduce these risks, some degree of risk would remain.

Environmental impacts associated with Alternative 3 are substantial due to the construction of the access road and capping activities occurring within the off-source area wetlands. Significant impact to the wetlands contained in the off-source area would occur as a result of the implementation of this alternative. The placement of capping material over contaminated sediments would impact portions of tidal channels by covering contaminated areas with 1 foot of clean fine-grained fill. These capping activities could significantly alter the majority of affected tidal channels in the short term.

9.5.4 Alternative 4: Removal

Alternative 4 would not be effective in the short term. The greatest short-term risks associated with Alternative 4 arise during the construction of the roadways into the off-source area and during dredging operations. The use of heavy machinery in soft soils such as the soils present in the off-source area poses a legitimate risk to workers involved in the implementation of this alternative. The construction of a 200 foot by 200 foot retention pond at the foot of the landfill would also pose risks to workers. Treatment of wastewater resulting from dewatering operations is expected to present minimal risk to workers.

Environmental impacts associated with Alternative 4 are substantial due to the construction and dredging activities occurring within the off-source area wetlands. Significant impact to the wetlands contained in the off-source area would occur as a result of the implementation of this alternative. The construction of roadways and a sediment dewatering pond within the off-source area would act to destroy approximately 240,000 square feet (5.5 acres) of wetland area.

9.5.5 Comparison of Alternatives

Alternative 2 has good short-term effectiveness given adequate maintenance of controls by the Tribes. Active remedies such as Alternatives 3 and 4 are likely to have poor short-term effectiveness because of the negative physical impacts to the wetlands during construction. Alternative 1 would not be effective because collection of shellfish from contaminated areas would not be prohibited.

9.6 Implementability

9.6.1 Alternative 1: No-Action

The no-action alternative is readily implementable. The inherent lack of any active remedial efforts or institutional control requirements makes Alternative 1 easily implementable.

9.6.2 Alternative 2: Institutional Controls

Alternative 2 is considered to be readily implementable. The technical and administrative aspects of Alternative 2 are considered minimal. The inherent lack of any active remedial efforts or additional monitoring requirements makes Alternative 2 easy to implement. Additional signage as necessary would be posted by the Tribes or a potentially responsible party, in and around the off-source area by the use of manual labor, boats, and rafts. This technology is immediately available for use at the Tulalip Landfill site. Monitoring in the off-source area is already required by the interim remedial action ROD.

Because Alternative 2 would result in hazardous substances remaining on the site above health-based levels, a statutory review would be conducted no less often than every five years after commencement of remedial action, to ensure that the remedy continues to provide adequate protection of human health and the environment.

9.6.3 Alternative 3: Capping

The technical and administrative aspects of Alternative 3 are readily implementable but have inherent difficulties. The reliability of Alternative 3 for the tidal channel sediments is dependent on the degree to which the capping system is maintained. The construction of the perimeter roadway may present some difficulties due to the construction requirements of the off-source areas soft soils. The need to relocate the capping equipment and pipelines to nine different locations would also present implementation difficulties. The wetland area is soft and presents challenges in moving personnel and equipment over its surface. Soft sediments make overland travel difficult and would require the placement of swamp mats or similar devices over the soft soil to provide a firm surface. Even with these mats, additional supports such as planks would be needed. This technology is immediately available for full-scale use.

9.6.4 Alternative 4: Removal

The extensive construction and sediment dewatering requirements of Alternative 4 present substantial implementation difficulties. Construction of roadways and dewatering facilities within the off-source area is expected to pose significant difficulties due to extremely soft soil conditions. Dredging operations within the off-source area wetlands will involve substantial technical and administrative requirements. Dredged sediments must be acceptable to a landfill before they are transported. The required technology to construct Alternative 4 is readily available.

9.6.5 Comparison of Alternatives

Active remediation of the wetlands such as capping (Alternative 3) or removing contamination (Alternative 4) would be technically very difficult due to the soft soil/sediment present. To provide access to the impacted areas, Alternatives 3 and 4 would require construction of roads and other facilities in addition to significant disturbance of the sediment. The damage to the wetlands would significantly outweigh the benefits of the cleanup. Also, remediation in such a difficult area makes control of contaminant releases during remediation difficult. The potential exists for contamination to be spread to other areas, making cleanup less effective. As discussed above, Alternatives 1 and 2 would be relatively simple to implement.

9.7 Cost

9.7.1 Alternative 1: No-Action

There is no cost associated with this alternative.

9.7.2 Alternative 2: Institutional Controls

The capital cost for this alternative is $15,410. Details are shown in **Table 6**. Since the operation and maintenance (O/M) cost would be minimal for this alternative, the estimated present worth would be equal to the capital cost.

Table 6 - Detailed Costs for Alternative 2: Institutional Controls/Natural Recovery

Item	Unit	No. Units	Cost/Unit	Total Cost
Mobilization				
Mobilize	Lump Sum	1	$5,000	$5,000
Sign Placement				
Signs	Each	48	$50	$2,400
Boat and operator	Day	8	$500	$4,000
Laborers	Day	8	$250	$2,000
Subtotal				**$13,400**
Engineering	Percent	5%		$670
Contingency	Percent	10%		$1,340
Total Cost				**$15,410**

9.7.3 Alternative 3: Capping

The capital cost for this alternative is $1,575,450. Details are shown in **Table 7**. Since the operation and maintenance (O/M) cost would be minimal for this alternative, the estimated present worth would be equal to the capital cost.

Table 7 - Detailed Cost for Alternative 3: Capping

Item	Unit	No. Units	Cost/Unit	Total Cost
Mobilization				
Mobilize equipment	Lump Sum (LS)	1	$30,000	$30,000
Trailer rental	Mo.	3	$400	$1,200
Office services	Mo.	3	$600	$1,800
Access Road Construction				
Fill	C.Y.	18,000	$8	$144,000
Dozer	Mo.	1	$5,000	$5,000
Excavator	Mo.	1	$4,000	$4,000
Laborers	Day	20	$750	$15,000
Operators	Day	20	$700	$14,000
Geotextile	Sq. Ft.	164,000	$0.05	$8,200
Capping Wetlands				
Sand pump rental	Mo.	2	$6,000	$12,000
Excavator rental	Mo.	1.5	$6,000	$9,000
Swamp mats	LS	1	$7,000	$7,000
Cap fill	C.Y.	3,100	$8	$24,800
Laborers	Day	36	$750	$27,000
Operators	Day	36	$350	$12,600
Pipe rental	LS	1	$10,000	$10,000
Capping Seep Soil				
Excavator rental	Mo.	1	$6,000	$6,000
Dozer	Mo.	1	$5,000	$5,000
Cap fill	C.Y.	9,400	$8	$75,200
Laborers	Day	20	$500	$10,000
Operators	Day	20	$700	$14,000
Soil transport and disposal	C.Y.	9,400	$70	$658,000
Field Supervision				
Field supervisor	Day	60	$720	$43,200
Health and safety officer	Day	60	$500	$30,000
Subtotal				**$1,167,000**
Engineering	%	15		$175,050
Contingency	%	20		$233,400
Total Cost				**$1,575,450**

9.7.4 Alternative 4: Removal

The capital cost for this alternative is $2,529,900. Details are shown in **Table 8**. Since the operation and maintenance (O/M) cost would be minimal for this alternative, the estimated present worth would be equal to the capital cost.

Table 8 - Detailed Cost for Alternative 4: Removal and Off-site Disposal

Item	Unit	No. Units	Cost/Unit	Total Cost
Mobilization				
Mobilize equipment	Lump Sum (LS)	1	$60,000	$60,000
Trailer rental	Mo.	4	$400	$1,600
Office services	Mo.	4	$600	$2,400
Access Road Construction				
Fill	C.Y.	22,000	$8	$176,000
Dozer	Mo.	2	$5,000	$10,000
Excavator	Mo.	2	$4,000	$8,000
Laborers	Day	40	$750	$30,000
Operators	Day	40	$700	$28,000
Geotextile	Sq. Ft.	200,000	$0.05	$10,000
Dredging				
Dredge rental	Mo.	2	$35,000	$70,000
Crane rental	Mo.	2	$7,000	$14,000
Dewatering pond	LS	1	$60,000	$60,000
Swamp mats	LS	1	$7,000	$7,000
Stabilization	C.Y.	3,100	$40	$124,000
Laborers	Day	40	$750	$30,000
Operators	Day	40	$700	$28,000
Loadout	C.Y.	4,600	$2	$9,200
Transport and dispose	C.Y.	4,600	$70	$322,000
Water treatment	Gallon	600,000	$0.03	$18,000
Capping Seep Soil				
Excavator rental	Mo.	1	$6,000	$6,000
Dozer	Mo.	1	$5,000	$5,000
Cap fill	C.Y.	9,400	$8	$75,200
Laborers	Day	20	$500	$10,000
Operators	Day	20	$700	$14,000
Soil transport and disposal	C.Y.	9,400	$70	$658,000
Field Supervision				
Field supervisor	Day	80	$720	$57,600
Health and safety officer	Day	80	$500	$40,000
	Subtotal			**$1,874,000**
Engineering	%	15		$281,100
Contingency	%	20		$374,800
	Total Cost			**$2,529,900**

9.7.5 Comparison of Alternatives

The cost of active remediation such as Alternatives 3 and 4, is high compared to the benefits likely to be gained from the cleanup. The relatively high cost is due to construction difficulties associated with the soft sediment and unstable soil. Alternative 2 is inexpensive and is very cost effective.

9.8 Tribal Acceptance

The Tulalip Tribes supports the implementation of Alternative 2.

9.9 Community Acceptance

No comments were received from the general public.

9.10 Summary of Comparison Analysis of Alternatives

Based upon the information contained above and comments from the Tulalip Tribes and the public, **Table 9** contains a summary of EPA's comparison analysis. This summary is based upon comparing the alternatives to each of the nine evaluation criteria.

Table 9 - Evaluation of Alternatives

	Alternative			
	-1- No Action	-2- Institutional Controls	-3- Capping	-4- Removal
1) Overall Protection of Human Health and the Environment	**Not Protective**	**Protective**	**Protective**	**Protective**
2) Compliance with ARARs	**Yes**	**Yes**	**No**	**No**
3) Long-term Effectiveness	**Moderately Effective**	**Moderately Effective**	**Effective**	**Effective**
4) Reduction Through Treatment	**None**	**None**	**None**	**None**
5) Short-term Effectiveness	**Not Effective**	**Moderately Effective**	**Not Effective**	**Not Effective**
6) Implementability	**Simple**	**Simple**	**Difficult**	**Difficult**
7) Cost	**$0**	**$15,410**	**$1,575,450**	**$2,529,900**
8) Tribal Acceptance	**No**	**Yes**	**No**	**No**
9) Community Acceptance	**No Comment**	**No Comment**	**No Comment**	**No Comment**

10.0 SELECTED REMEDY

10.1 The On-source Remedy

The final remedy for this area is the remedy previously documented in the March 1996 interim ROD. This remedy continues to be protective of human health and the environment by containing and preventing contact with the landfill wastes. Major elements of the final on-source remedy (the previous remedy selected in the interim ROD) include:

- Capping the landfill in accordance with the Washington State Minimum Functional Standards for landfill closure.

- Installing a landfill gas collection system. If necessary, a gas treatment system will also be installed.

- Monitoring the leachate mound within the landfill, the perimeter leachate seeps, and landfill gas to ensure the selected remedy is adequately containing the landfill wastes.

- Land use restrictions to protect the landfill cap.

- Providing for operation and maintenance (O&M) to ensure the integrity of the cap system.

The final selected remedy for the on-source area is expected to stem the migration of contaminants from the landfill into the surrounding estuary by minimizing the amount of rain water infiltrating the wastes, thereby minimizing the generation of new leachate. The remedial design for the on-source cover system was completed on May 6, 1998. Construction of the cover system was initiated immediately after the design approval and will take approximately 2 years to complete. The ARARs presented in the Interim ROD are still applicable or relevant and appropriate.

10.2 The Off-source Remedy

The selected remedy for the off-source area (wetlands), is institutional controls. This selection assumes the completion of the on-source remedy. Institutional controls would protect human health by warning of the potential dangers associated with the eating of fish and shellfish from the affected area. In addition, the potential for this type of exposure is relatively low given the site setting and access difficulties. Natural attenuation of the organics and inorganics in the tidal channel sediment would protect the marine receptors. Seep area soil that presently exists above background concentrations would present a small and decreasing incremental ecological risk to plants and soil-dwelling organisms following source control. This incremental risk is not significant since it affects a small percentage of the off-source area.

This alternative consists of maintaining existing signs, and as necessary, posting new signs along the perimeter of the sloughs and landfill warning of the potential risk from harvesting and eating fish and shellfish. Signs would be located approximately every 300 to 600 feet along Steamboat Slough and

Ebey Slough. The Tulalip Tribes or the PRPs would be responsible for installing any required new signs. Following construction of the cover system (source control), natural recovery would reduce the concentrations of organics and inorganics.

Inspections of the site would be performed to ensure the warning signs were still in place and readable. The Tulalip Tribes would be responsible for maintenance and enforcement of the signs. Periodic monitoring of the impacted sediment and seep soil is already required by the interim remedial action ROD. Monitoring would ensure the contaminants were attenuating and not migrating or increasing in concentrations.

EPA believes that it is essential to control and minimize the release of contaminants to the environment with the construction of the on-source cover system. The implementation of institutional controls in the surrounding off-source area will supplement the major remedy, the on-source remedy.

11.0 STATUTORY DETERMINATIONS

In combination, the on-source and off-source remedies selected in this ROD are protective of human health and the environment, comply with Federal, State, and Tribal requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost-effective. This remedial action utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for this site. However, the presumptive remedy approach for municipal landfills selected in the interim ROD utilizes the remedial approach of containment of wastes rather than treatment of wastes. Because treatment of the principal threats of the site was not found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principal element of the remedy.

11.1 Protection of Human Health and the Environment

In combination, the final on-source and off-source remedies selected in this ROD are protective of human health and the environment. The final remedy will permanently reduce the risks presently posed to human health and the environment by preventing contact with waste using a low permeability cover and institutional controls. The low permeabilty cover will also minimize infiltration, thus reducing the possibility of seep contact, seep migration, and groundwater migration. As a result, the final remedial action will also be protective of human health and the environment in the long term.

11.2 Applicable, Relevant and Appropriate Requirements (ARARs)

The selected remedy will comply with all Federal, State and Tribal legally applicable, relevant and appropriate requirements. For the on-source remedy, the ARARs presented in the interim ROD are still applicable, or revelevant and appropriate. Since the Tulalip Landfill is located on Tribal property, state regulatory requirements do not necessarily apply to work performed in this location. However, compliance with the Federal regulations and the substantive portions of State regulations is prudent to protect the environment.

11.2.1 Relevant and Appropriate Requirements

<u>Washington Sediment Management Standards (WAC 173-204)</u> are relevant and appropriate requirements for the off-source remedial action. The Washington Sediment Management Standards establish numerical values for chemical constituents in sediments. These standards are not legally applicable, because the site is located on Tribal lands where State requirements are not enforceable. However, the standards are relevant and appropriate because their purpose is to provide standards for determining acceptable levels of contaminants in sediments. The selected remedial action for the off-source area complies with these standards because, following source control, natural recovery will reduce the concentrations of organics and inorganics.

11.2.2 To-Be-Considered (TBC)

<u>Executive Order 11990 ("Protection of Wetlands"), as implemented by 40 C.F.R. Part 6, Appendix A</u> is a TBC for the off-source remedial action. Within and adjacent to wetlands, Executive Order 11990 directs actions to be performed so as to minimize the destruction, loss, or degradation of wetlands. The off-source area of the site consists of ecologically productive wetlands, and Executive Order 11990 is, therefore, to be considered in selecting a remedy for the off-source area that results in minimal destruction of, or impact to, these valuable wetlands.

11.3 Cost-Effectiveness

The selected remedy is cost-effective because it provides overall effectiveness proportional to its costs such that it represents a reasonable value for the money to be spent.

11.4 Utilization of Permanent Solutions and Treatment Technologies to the Maximum Extent Practicable

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner at this site. The selected remedy provides the best balance of tradeoffs among the alternatives with respect to the evaluation criteria. For the off-source area, the criteria that were most critical in the selection decision were short-term effectiveness, long-term effectiveness and Tribal acceptability. Treatment was found to be impracticable for the lower threat materials in the off-source area. The remedy selected for the on-source area applied the presumptive remedy approach for municipal-type landfills, which utilizes the remedial approach of containment of wastes rather than treatment of wastes.

11.5 Preference for Treatment as a Principal Element

The selected remedy does not meet the statutory preference for treatment of a principal threat. The material in the off-source area is not a principal threat, as that term is used in EPA guidance. Treatment of this lower threat material has been found to be impracticable. The remedy selected for the on-source area applied the presumptive remedy approach for municipal-type landfills, which utilizes the remedial approach of containment of wastes rather than treatment of wastes.

11.6 Five-year Reviews

Because this remedial action will result in hazardous substances remaining on the site above health-based levels, a statutory review will be conducted no less often than every five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

12.0 Documentation of Significant Changes

No significant changes to the remedy, as originally identified in the Proposed Plan, were necessary.

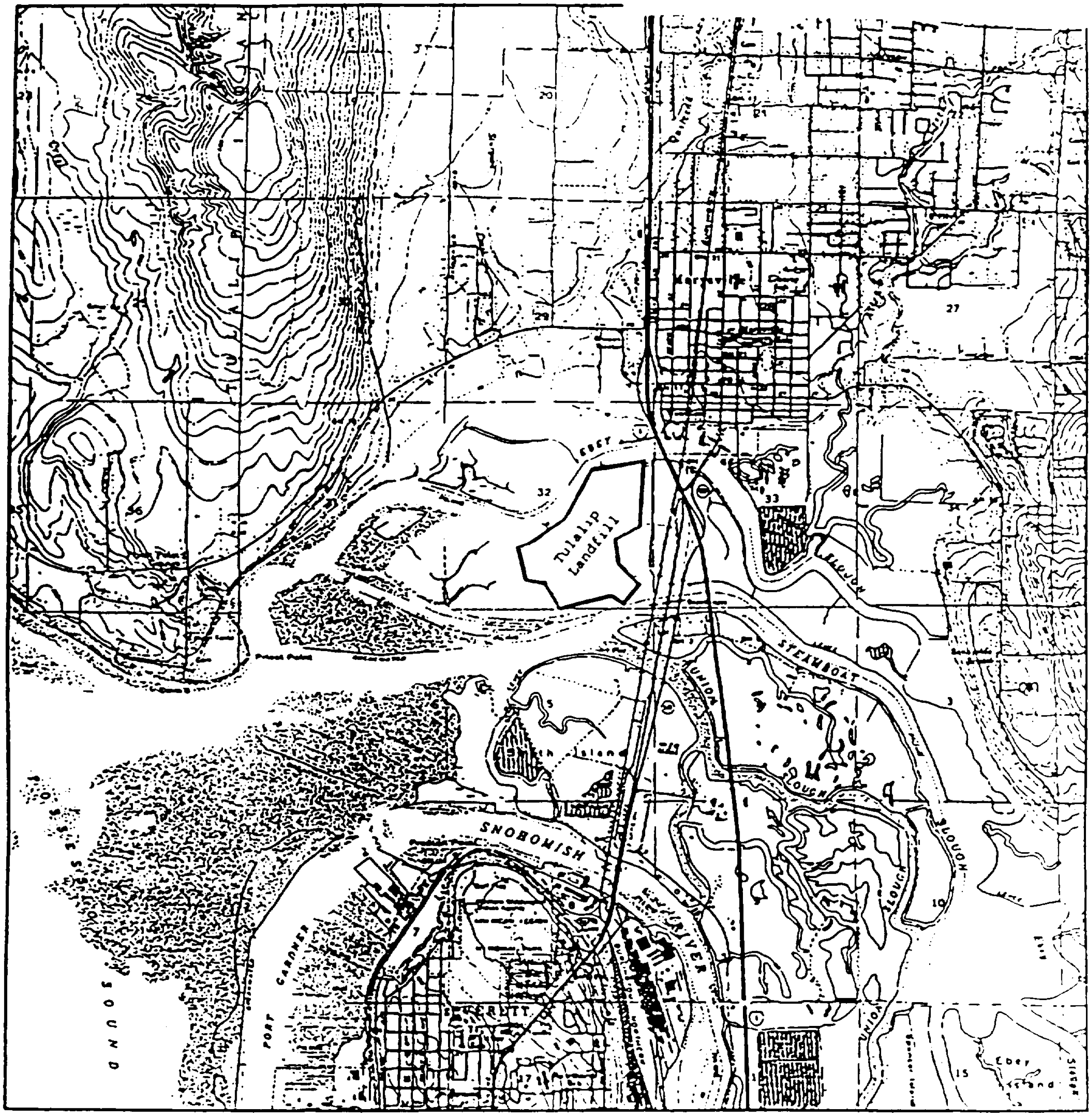
13.0 RESPONSIVENESS SUMMARY

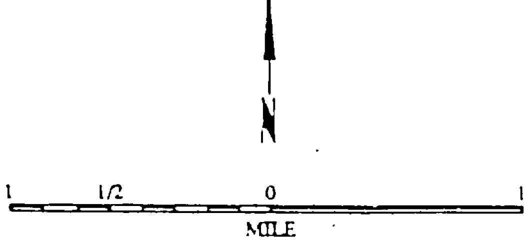
EPA held the required 30-day public comment period for the Tulalip Landfill Off-Source Proposed Plan from August 3, 1998 through September 1, 1998. The Proposed Plan was mailed to the 415 people on EPA's Tulalip Landfill Superfund mailing list on August 3, 1998. An announcement of the availability of the Proposed Plan, a summary of the plan and information on how to get more information was published in a display advertisement in the Everett Herald on August 3, 1998. Both the Proposed Plan and the Everett Herald notice indicated that readers could request that the EPA hold a public meeting to discuss the plan.

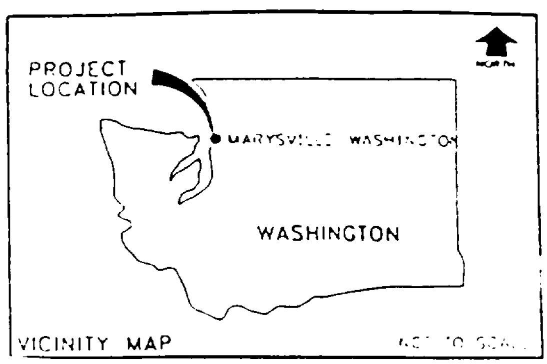
EPA received one written comment on the plan. No verbal comments or requests for a public meeting about the plan were received. The written comment was from the Tulalip Tribes. In their comment letter the Tulalip Tribes indicated their support for EPA's preferred alternative of institutional controls.

TULALIP LANDFILL
FIGURES

Figure 1

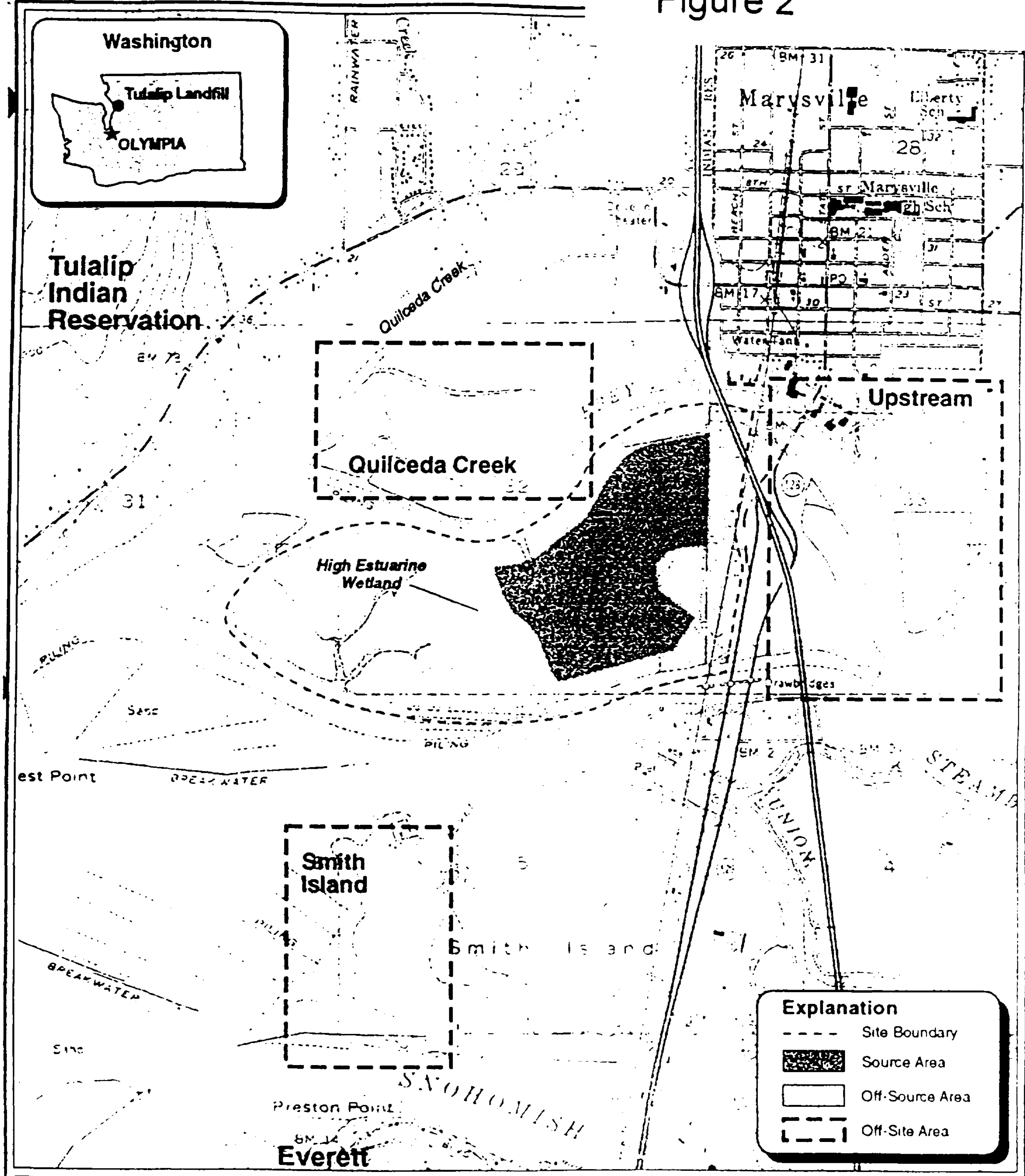






SITE LOCATION MAP

Figure 2



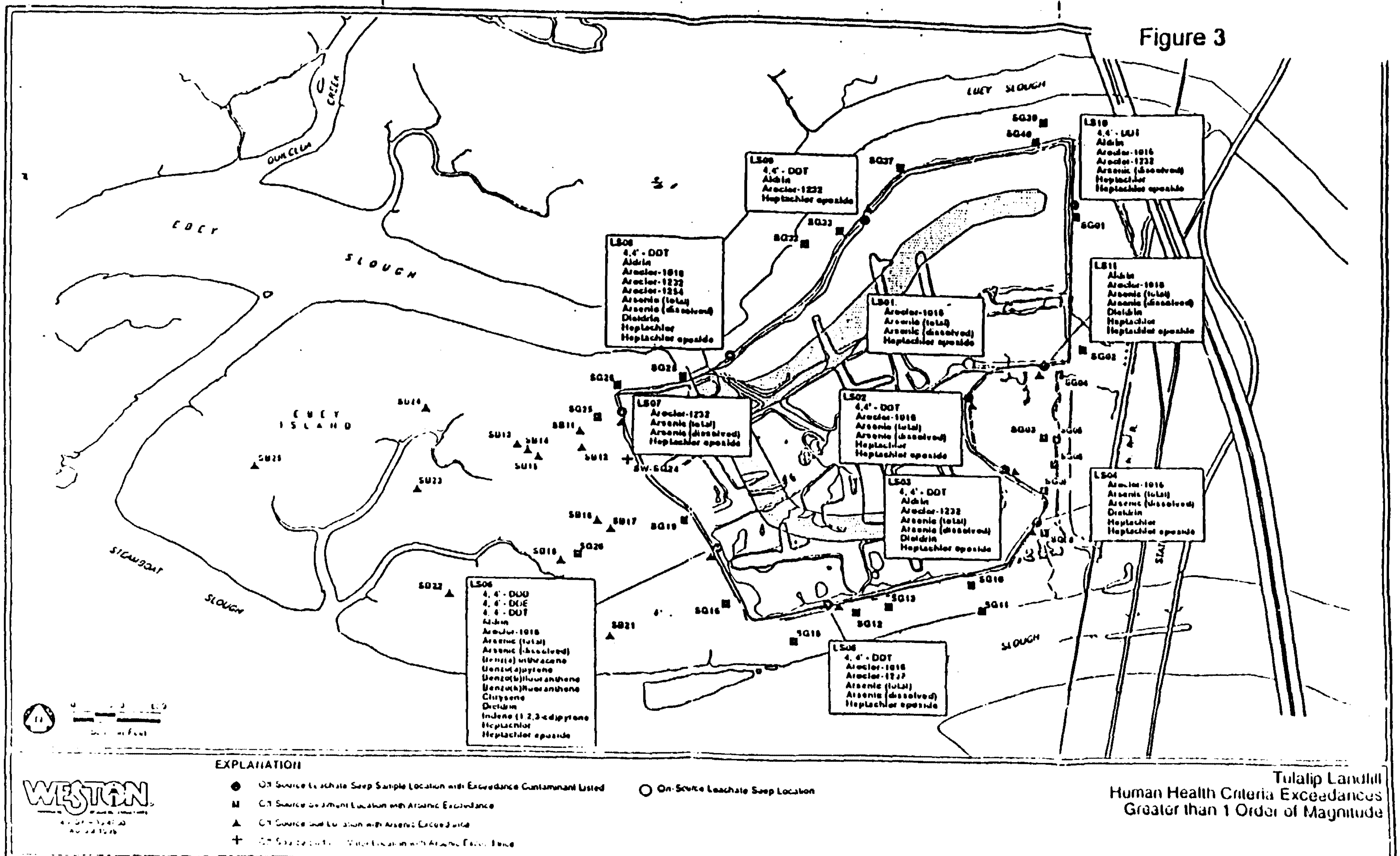
0 1000 2000
Scale in Feet

Source: USGS 7 1/2' Quadrangle Series—Marysville, WA (1956, PR73)

Tulalip Landfill
Delineation of Source, Off-Source and Off-Site Areas

WESTON

96-933 Fig3-6 th5



EDEY SLOUGH
QUILCEDA CREEK
EBEY ISLAND
STEAMBOAT SLOUGH
EBEY SLOUGH
SLOUGH
LS10
4,4' - DDT
Aldrin
Aroclor-1016
Aroclor-1232
Arsenic (dissolved)
Heptachlor
Heptachlor epoxide
LS09
4,4' - DDT
Aldrin
Aroclor-1232
Heptachlor epoxide
LS08
4,4' - DDT
Aldrin
Aroclor-1016
Aroclor-1232
Aroclor-1254
Arsenic (total)
Arsenic (dissolved)
Dieldrin
Heptachlor
Heptachlor epoxide
LS01
Aroclor-1016
Arsenic (total)
Arsenic (dissolved)
Heptachlor epoxide
LS11
Aldrin
Aroclor-1016
Arsenic (total)
Arsenic (dissolved)
Dieldrin
Heptachlor
Heptachlor epoxide
LS07
Aroclor-1232
Arsenic (total)
Arsenic (dissolved)
Heptachlor epoxide
LS02
4,4' - DDT
Aroclor-1016
Arsenic (total)
Arsenic (dissolved)
Heptachlor
Heptachlor epoxide
LS03
4,4' - DDT
Aldrin
Aroclor-1232
Arsenic (total)
Arsenic (dissolved)
Dieldrin
Heptachlor epoxide
LS04
Aroclor-1016
Arsenic (total)
Arsenic (dissolved)
Dieldrin
Heptachlor
Heptachlor epoxide
LS06
4, 4' - DDD
4, 4' - DDE
4, 4' - DDT
Aldrin
Aroclor-1016
Arsenic (total)
Arsenic (dissolved)
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Chrysene
Dieldrin
Indeno (1,2,3-cd)pyrene
Heptachlor
Heptachlor epoxide
LS05
4, 4' - DDT
Aroclor-1016
Arsenic (total)
Arsenic (dissolved)
Heptachlor epoxide
SQ01
SQ02
SQ03
SQ04
SQ10
SQ11
SQ12
SQ13
SQ15
SQ16
SQ19
SQ20
SQ22
SQ25
SQ26
SQ28
SQ32
SQ33
SQ37
SQ39
SQ40
SU11
SU12
SU13
SU14
SU15
SU16
SU17
SU18
SU21
SU23
SU24
SU25
SW-SG24
EXPLANATION
On-Source Leachate Seep Location
WESTON
Tulalip Landfill
Human Health Criteria Exceedances
Greater than 1 Order of Magnitude

Figure 3

Figure 4

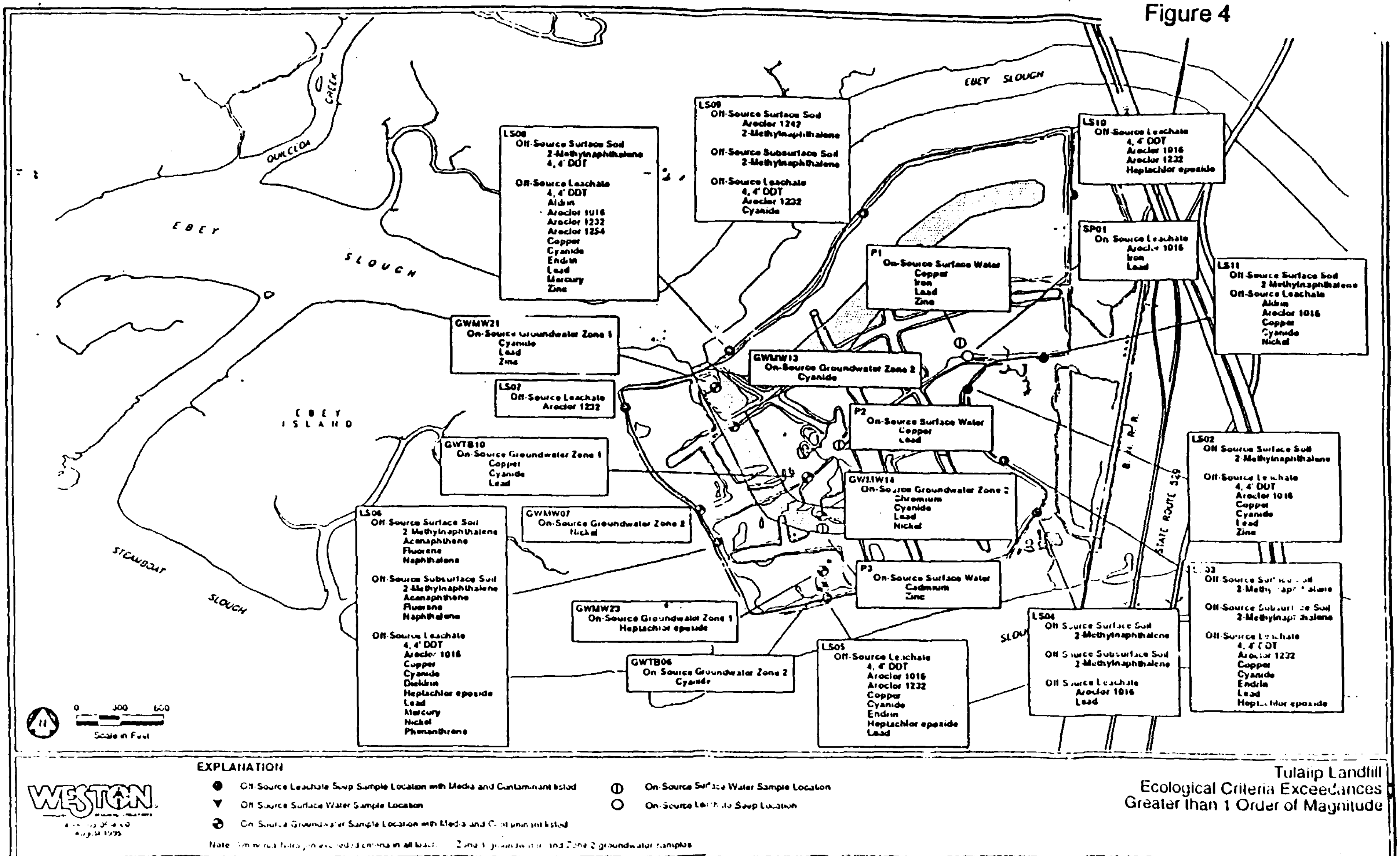
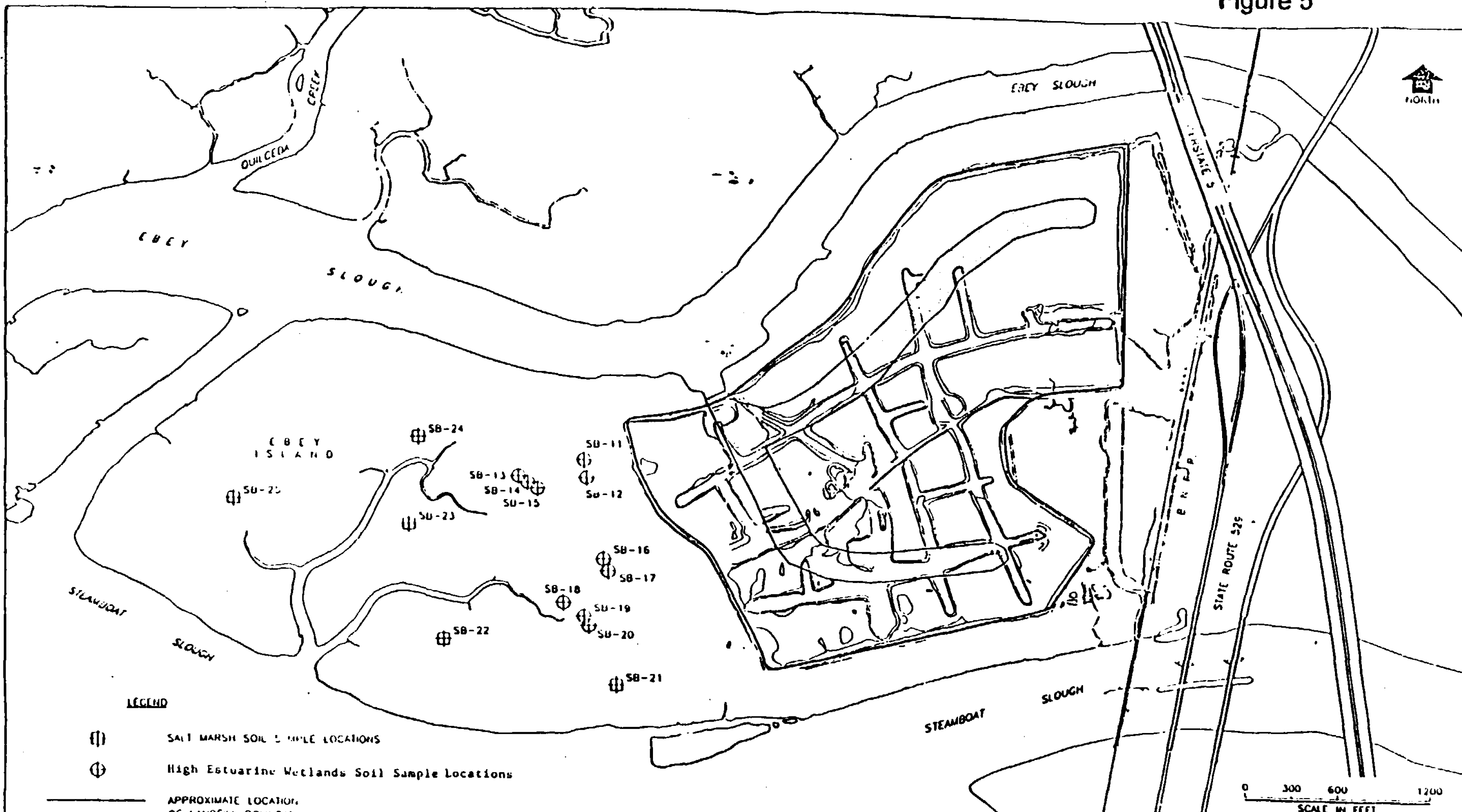

EBEY SLOUGH
QUILCEDA CREEK
EBEY SLOUGH
EBEY ISLAND
STEAMBOAT SLOUGH
STATE ROUTE 529
LS08
Off-Source Surface Soil
2-Methylnaphthalene
4, 4' DDT
Off-Source Leachate
4, 4' DDT
Aldrin
Aroclor 1016
Aroclor 1232
Aroclor 1254
Copper
Cyanide
Endrin
Lead
Mercury
Zinc
LS09
Off-Source Surface Soil
Aroclor 1242
2-Methylnaphthalene
Off-Source Subsurface Soil
2-Methylnaphthalene
Off-Source Leachate
4, 4' DDT
Aroclor 1232
Cyanide
LS10
Off-Source Leachate
4, 4' DDT
Aroclor 1016
Aroclor 1232
Heptachlor epoxide
SP01
Off-Source Leachate
Aroclor 1016
Iron
Lead
P1
On-Source Surface Water
Copper
Iron
Lead
Zinc
LS11
Off-Source Surface Soil
2-Methylnaphthalene
Off-Source Leachate
Aldrin
Aroclor 1016
Copper
Cyanide
Nickel
GWMW21
On-Source Groundwater Zone 1
Cyanide
Lead
Zinc
GWMW13
On-Source Groundwater Zone 2
Cyanide
LS07
Off-Source Leachate
Aroclor 1232
P2
On-Source Surface Water
Copper
Lead
GWTB10
On-Source Groundwater Zone 1
Copper
Cyanide
Lead
GWMW14
On-Source Groundwater Zone 2
Chromium
Cyanide
Lead
Nickel
LS02
Off-Source Surface Soil
2-Methylnaphthalene
Off-Source Leachate
4, 4' DDT
Aroclor 1016
Copper
Cyanide
Lead
Zinc
LS06
Off-Source Surface Soil
2-Methylnaphthalene
Acenaphthene
Fluorene
Naphthalene
Off-Source Subsurface Soil
2-Methylnaphthalene
Acenaphthene
Fluorene
Naphthalene
Off-Source Leachate
4, 4' DDT
Aroclor 1016
Copper
Cyanide
Dieldrin
Heptachlor epoxide
Lead
Mercury
Nickel
Phenanthrene
GWMW07
On-Source Groundwater Zone 2
Nickel
P3
On-Source Surface Water
Cadmium
Zinc
GWMW23
On-Source Groundwater Zone 1
Heptachlor epoxide
LS04
Off-Source Surface Soil
2-Methylnaphthalene
Off-Source Subsurface Soil
2-Methylnaphthalene
Off-Source Leachate
Aroclor 1016
Lead
Off-Source Surface Soil
2-Methylnaphthalene
Off-Source Subsurface Soil
2-Methylnaphthalene
Off-Source Leachate
4, 4' DDT
Aroclor 1232
Copper
Cyanide
Endrin
Lead
Heptachlor epoxide
GWTB06
On-Source Groundwater Zone 2
Cyanide
LS05
Off-Source Leachate
4, 4' DDT
Aroclor 1016
Aroclor 1232
Copper
Cyanide
Endrin
Heptachlor epoxide
Lead
0 300 600
Scale in Feet
EXPLANATION
Off-Source Leachate Seep Sample Location with Media and Contaminant listed
Off-Source Surface Water Sample Location
On-Source Groundwater Sample Location with Media and Contaminant listed
On-Source Surface Water Sample Location
On-Source Leachate Seep Location
WESTON
Tulalip Landfill
Ecological Criteria Exceedances
Greater than 1 Order of Magnitude

Figure 5



LEGEND

SALT MARSH SOIL SAMPLE LOCATIONS

High Estuarine Wetlands Soil Sample Locations

APPROXIMATE LOCATION OF LANDFILL BOUNDARY

BARGE CANAL LOCATION

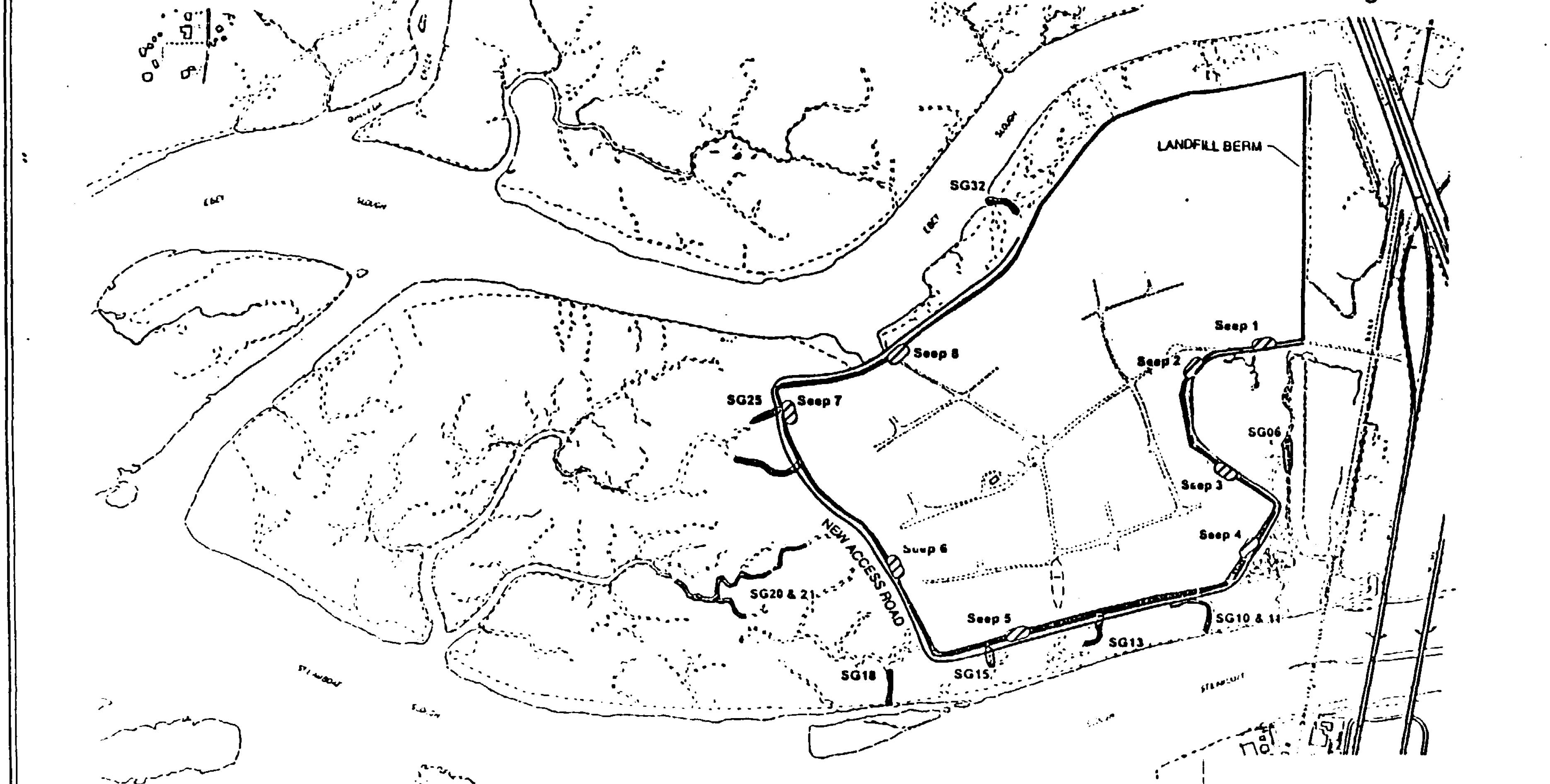
SOURCE: U.S. ARMY CORPS OF ENGINEERS, U.S. ENVIRONMENTAL PROTECTION AGENCY
DATE OF MAP PREPARATION 11/92

HARDING LAWSON ASSOCIATES
Engineering and Environmental Services

High Estuarine Wetlands and Salt Marsh Soil Sample Locations
Remedial Investigation Report
Tulalip Landfill
Marysville, Washington

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
DC	26535		12/94	

Figure 6



0 300 600
Scale in Feet

EXPLANATION

SG25 Sediment Remediation Areas

Seep 7 Seep and Soil

WESTON

Tulalip Landfill
Off-Source Remediation Areas

TULALIP LANDFILL
A - TABLES

Table A-1

Chemicals Detected in On-Source and Off-Source Media

Analyte	On-Source Media				Off-Source Media								
	Zone 1 Groundwater	Zone 2 Groundwater	Surface Water	Surface Soil	Surface Soil	Subsurface Soil	Surface Water	Leachate Seep[1]	Surface Sediment	Subsurface Sediment	Fish Tissue	Clams	Small Mammal Tissue
VOCs													
1,1-Dichloroethane		✓						✓					
2-Butanone		✓											
2-Hexanone		✓											
4-Methyl-2-Pentanone								✓					
Acetone		✓	✓				✓	✓					
Benzene	✓	✓	✓					✓					
Butylbenzene								✓					
Carbon Disulfide		✓											
Chlorobenzene	✓	✓	✓					✓					
Chloroethane								✓					
Chloroform		✓											
Chloromethane	✓	✓					✓	✓					
cis-1,2-Dichloroethene								✓					
Ethylbenzene	✓	✓	✓					✓					
Methylene Chloride		✓						✓					
Toluene	✓	✓	✓					✓					
Total Xylenes	✓	✓	✓					✓					
Trichloroethene			✓										
BNAs													
1,2,4-Trichlorobenzene								✓					
1,2-Dichlorobenzene	✓							✓					
1,3-Dichlorobenzene	✓							✓					
1,4-Dichlorobenzene	✓	✓	✓		✓	✓		✓					
2,4-Dichlorophenol			✓					✓					
2,4-Dimethylphenol	✓		✓		✓	✓		✓					
1-Methylnaphthalene					✓	✓							
2-Methylnaphthalene	✓	✓	✓		✓	✓		✓	✓	✓			
2-Methylphenol	✓							✓					
3,3'-Dichlorobenzidine								✓					
4-Chloro-3-methylphenol								✓					
4-Methylphenol	✓	✓			✓	✓		✓	✓	✓			
4-Nitrophenol				✓									
Acenaphthylene					✓	✓		✓	✓	✓			
Acenapthene	✓	✓	✓		✓	✓		✓	✓	✓		✓	
Anthracene	✓	✓			✓	✓		✓	✓	✓		✓	
Benzo(a)anthracene			✓		✓	✓		✓	✓	✓		✓	

Chemicals Detected in On-Source and Off-Source Media

Analyte	On-Source Media				Off-Source Media								
	Zone 1 Groundwater	Zone 2 Groundwater	Surface Water	Surface Soil	Surface Soil	Subsurface Soil	Surface Water	Leachate Seep[1]	Surface Sediment	Subsurface Sediment	Fish Tissue	Clams	Small Mammal Tissue
Benzo(a)pyrene		✓			✓	✓		✓	✓	✓		✓	
Benzo(b)fluoranthene					✓	✓		✓	✓	✓		✓	
Benzo(g,h,i)perylene					✓	✓		✓	✓	✓		✓	
Benzo(k)fluoranthene					✓	✓		✓	✓	✓		✓	
Benzoic acid								✓	✓	✓			
bis(2-Chloroethyl)ether									✓				
bis(2-Ethylhexyl)phthalate		✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Butylbenzylphthalate					✓								
Carbazole					✓	✓		✓	✓	✓			
Chrysene			✓	✓	✓	✓		✓	✓	✓		✓	
Di-n-butylphthalate		✓			✓			✓		✓			
Di-n-octylphthalate			✓	✓	✓	✓		✓					
Dibenz(a,h)anthracene					✓		✓	✓	✓	✓		✓	
Dibenzofuran	✓	✓	✓		✓	✓		✓	✓	✓			
Diethylphthalate	✓	✓						✓					
Dimethylphthalate					✓								
Fluoranthene	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	
Fluorene	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	
Indeno(1,2,3-cd)pyrene					✓	✓		✓	✓	✓		✓	
n-Nitrosodiphenylamine	✓				✓	✓		✓					
n-Nitroso-di-n-propylamine				✓									
Naphthalene	✓	✓	✓	✓	✓	✓		✓	✓	✓			
Pentachlorophenol						✓							
Phenanthrene	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	
Phenol	✓	✓			✓			✓	✓				
Pyrene		✓	✓	✓	✓	✓		✓	✓	✓		✓	
PCB/Pesticides													
4,4'-DDD					✓	✓		✓	✓	✓		✓	✓
4,4'-DDE								✓	✓	✓		✓	✓
4,4'-DDT					✓			✓		✓		✓	✓
Aldrin					✓	✓		✓	✓				
Aroclor-1016					✓			✓					
Aroclor-1232								✓					
Aroclor-1242					✓	✓							
Aroclor-1248					✓								
Aroclor-1254					✓	✓		✓					
Aroclor-1260					✓	✓							✓

Chemicals Detected in On-Source and Off-Source Media

Analyte	On Source Media				Off-Source Media								
	Zone 1 Groundwater	Zone 2 Groundwater	Surface Water	Surface Soil	Surface Soil	Subsurface Soil	Surface Water	Leachate Seep'	Surface Sediment	Subsurface Sediment	Fish Tissue	Clams	Small Mammal Tissue
alpha-BHC									✓				
beta-BHC		✓			✓			✓	✓	✓		✓	✓
delta-BHC	✓	✓			✓			✓	✓	✓		✓	
gamma-BHC (Lindane)	✓				✓	✓		✓	✓	✓			
Dieldrin					✓			✓	✓	✓		✓	
Endosulfan I					✓			✓	✓	✓			✓
Endosulfan II		✓						✓	✓			✓	✓
Endosulfan sulfate					✓			✓					✓
Endrin								✓	✓	✓			✓
Endrin aldehyde		✓			✓			✓		✓			
Endrin ketone					✓	✓			✓				
gamma-chlordane								✓				✓	
Heptachlor		✓			✓			✓	✓	✓		✓	
Heptachlor epoxide	✓				✓	✓		✓	✓				
Methoxychlor								✓	✓				✓
INORGANICS													
Aluminum	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Antimony	✓	✓			✓			✓	✓		✓	✓	
Arsenic	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
Barium	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Beryllium	✓	✓	✓		✓	✓			✓	✓		✓	
Cadmium	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Calcium	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Chromium	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Cobalt	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Copper	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Cyanide	✓	✓	✓		✓	✓		✓					
Iron	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Lead	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Magnesium	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Manganese	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Mercury		✓			✓	✓		✓	✓	✓	✓	✓	✓
Nickel	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Potassium	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Selenium		✓			✓	✓		✓	✓	✓	✓	✓	✓
Silver					✓				✓		✓		
Sodium	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

Chemicals Detected in On-Source and Off-Source Media

Analyte	On-Source Media				Off-Source Media								
	Zone 1 Groundwater	Zone 2 Groundwater	Surface Water	Surface Soil	Surface Soil	Subsurface Soil	Surface Water	Leachate Seep[1]	Surface Sediment	Subsurface Sediment	Fish Tissue	Clams	Small Mammal Tissue
Thallium	✓	✓				✓		✓				✓	
Vanadium	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Zinc	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
CONVENTIONALS													
Ammonia Nitrogen	✓	✓						✓					

[1] Summary of on-source and off-source leachate seeps

Table A-2

Summary of Human Health Constituents of Potential Concern

Constituent	Purged Clams	Whole-Body Sculpin	Surface Soil/Sediment
Semivolatile Organics			
1-Methylnaphthalene			✓*
2-Methylnaphthalene			✓*
Acenaphthylene			✓*
Benzo(a)anthracene			✓
Benzo(a)pyrene			✓
Benzo(b)fluoranthene			✓
Benzo(g,h,i)perylene			✓*
Dibenz(a,h)anthracene			✓
Dibenzofuran			✓
Indeno(1,2,3-cd)pyrene			✓
Phenanthrene			✓*
Inorganics			
Aluminum		✓	✓
Antimony	✓		✓
Arsenic	✓	✓	✓
Barium			✓
Beryllium			✓
Cadmium	✓		
Lead	✓*	✓*	✓*
Manganese	✓	✓	✓
Nickel			✓
Selenium	✓		
Vanadium	✓		✓
Pesticides and PCBs			
4,4'-DDE	✓		
4,4'-DDT	✓		
Aroclor 1016			✓
Aroclor 1242			✓*
Aroclor 1248			✓*

Summary of Human Health Constituents of Potential Concern

Constituent	Purged Clams	Whole-Body Sculpin	Surface Soil/Sediment
Aroclor 1254		✓	✓
Aroclor 1260			✓*
delta-BHC			✓*
Dieldrin	✓		
Heptachlor epoxide			✓
Total PCBs		✓	✓

✓ Constituent selected as COPC for given medium. Will be further addressed in the CHHBRA.

* Inadequate toxicity information available, Constituent retained as COPC for further qualitative discussion in the CHHBRA

Table A-3

Summary of Ecological Constituents of Potential Concern

Constituent	Unpurged Clams	Sculpin Whole-Body	Small Mammals	Surface Soil	Subsurface Soil	Surface Sediment	Subsurface Sediment	Great Blue Heron	Northern Harrier
Semivolatile Organics									
1,4-Dichlorobenzene				✓*	✓*				
1-Methylnaphthalene					✓				
2,4-Dimethylphenol					✓*				
4-Chloro-3-Methylphenol							✓*		
2-Methylnaphthalene				✓	✓	✓	✓		
2-Methylphenol						✓	✓		
4-Methylphenol				✓	✓	✓	✓		
Acenaphthene	✓*			✓	✓	✓	✓		
Acenaphthylene				✓	✓	✓	✓		
Anthracene	✓*			✓	✓	✓	✓		
Benzo(a)anthracene	✓*			✓	✓	✓	✓		
Benzo(a)pyrene	✓*			✓	✓	✓	✓		
Benzo(b)fluoranthene	✓*			✓	✓	✓	✓		
Benzo(g,h,i)perylene	✓*			✓	✓	✓	✓		
Benzo(k)fluoranthene	✓*			✓	✓	✓	✓		
Benzoic acid							✓*		
bis(2-Ethylhexyl)phthalate			✓*	✓	✓	✓	✓		
Butylbenzylphthalate					✓				

Summary of Ecological Constituents of Potential Concern

Constituent	Unpurged Clams	Sculpin Whole-Body	Small Mammals	Surface Soil	Subsurface Soil	Surface Sediment	Subsurface Sediment	Great Blue Heron	Northern Harrier
Carbazole				✓*	✓*	✓*	✓*		
Chrysene	✓*			✓	✓	✓	✓		
Di-n-butylphthalate				✓	✓		✓		
Di-n-octylphthalate				✓	✓				
Dibenz(a,h)anthracene	✓*			✓	✓	✓	✓		
Dibenzofuran				✓*	✓*	✓	✓		
Diethylphthalate						✓	✓		
Dimethylphthalate					✓*				
Fluoranthene	✓*			✓	✓	✓	✓		
Fluorene	✓*			✓	✓	✓	✓		
Indeno(1,2,3-cd)pyrene	✓*			✓	✓	✓	✓		
N-Nitrosodiphenylmine				✓*	✓*				
Naphthalene				✓	✓	✓	✓		
Pentachlorophenol					✓				
Phenanthrene	✓*			✓	✓	✓	✓		
Phenol				✓		✓			
Pyrene	✓*			✓	✓	✓	✓		
Inorganics									
Aluminum	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Antimony	✓*			✓		✓			

—Summary of Ecological Constituents of Potential Concern

Constituent	Unpurged Clams	Sculpin Whole-Body	Small Mammals	Surface Soil	Subsurface Soil	Surface Sediment	Subsurface Sediment	Great Blue Heron	Northern Harrier
Arsenic	✓*	✓*		✓*	✓*	✓*	✓*		
Barium	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Beryllium	✓*			✓	✓	✓*	✓*		
Cadmium	✓*	✓*	✓*	✓	✓	✓	✓	✓*	✓*
Chromium	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Cobalt	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Copper	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Cyanide				✓*	✓*				
Lead	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*
Manganese	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Mercury	✓*	✓*	✓*	✓	✓	✓	✓	✓*	✓*
Nickel	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Selenium	✓*	✓*	✓*	✓	✓	✓*	✓*		
Silver		✓*		✓	✓	✓			
Thallium	✓*				✓				
Vanadium	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Zinc	✓*	✓*	✓*	✓*	✓*	✓*	✓*		
Pesticides and PCBs									
4,4'-DDD	✓*		✓*	✓	✓	✓	✓		✓*
4,4'-DDE	✓*		✓*			✓	✓		✓*

Summary of Ecological Constituents of Potential Concern

Constituent	Unpurged Clams	Sculpin Whole-Body	Small Mammals	Surface Soil	Subsurface Soil	Surface Sediment	Subsurface Sediment	Great Blue Heron	Northern Harrier
4,4'-DDT	✓*		✓*	✓	✓		✓		✓*
Aldrin				✓	✓	✓*	✓*		
alpha-BHC						✓*	✓*		
Aroclor 1016					✓				
Aroclor 1232							✓		
Aroclor 1242				✓	✓		✓		
Aroclor 1248				✓	✓				
Aroclor 1254		✓*		✓	✓			✓*	
Aroclor 1260			✓*	✓	✓				✓*
Total PCBs		✓*	✓*	✓	✓		✓	✓*	✓*
beta-BHC	✓*		✓*	✓		✓*	✓*		✓*
delta-BHC	✓*			✓	✓	✓*	✓*		
Dieldrin	✓*			✓		✓*	✓*		
Endosulfan I			✓*		✓	✓*	✓*		
Endosulfan II	✓*		✓*			✓*			
Endosulfan sulfate			✓*	✓					✓*
Endrin			✓*			✓*	✓*		✓*
Endrin aldehyde					✓		✓*		
Endrin ketone				✓	✓	✓*			
gamma-BHC (Lindane)				✓	✓	✓*	✓*		

Summary of Ecological Constituents of Potential Concern

Constituent	Unpurged Clams	Sculpin Whole-Body	Small Mammals	Surface Soil	Subsurface Soil	Surface Sediment	Subsurface Sediment	Great Blue Heron	Northern Harrier
gamma-Chlordane	✓*								
Heptachlor	✓*			✓		✓*	✓*		
Heptachlor epoxide					✓		✓*		
Methoxychlor		✓*	✓*			✓*		✓*	✓*

✓ = Constituent selected as COPC for given medium   Will be further addressed in the CBERA
* = Inadequate toxicity screening information available   Constituent retained as COPC for further quantitative/qualitative discussion in the CBERA

Table A-4

Total Carcinogenic and Noncarcinogenic RME Risks for Each Scenario

Exposure Pathway	Carcinogenic Risk				Noncarcinogenic Risk			
	Recreational User - Adult	Subsistance User - Adult	Subsistance User- Child	Combination* Adult Risk	Recreational User - Adult	Subsistance User - Adult	Subsistance User- Child	Combination* Adult Risk
Incidental Soil/Sediment Ingestion	6.5E-6	NA	NA	6.5E-6	0.026	NA	NA	0.026
Soil/Sediment Dermal Contact	6.9E-8	NA	NA	6.9E-8	0.0034	NA	NA	0.0034
Fish Ingestion	NA	9.3E-6	1.4E-8	9.3E-6	NA	0.13	0.0021	0.13
Shellfish Ingestion	NA	9.0E-4	2.7E-5	9.0E-4	NA	3.1	1.0	3.1
Total	6.6E-6	9.1E-4	2.7E-5	9.1E-4	0.030	3.3	1.0	3.3

* Combination includes risks from both subsistance consumption and recreational activity (such as hunting at the site)

Table A-5

Total Carcinogenic and Noncarcinogenic CTE Risks for Each Scenario

Exposure Pathway	Carcinogenic Effects				Noncarcinogenic Risk			
	Recreational User - Adult	Subsistance User - Adult	Subsistance User- Child	Combination* Adult Risk	Recreational User - Adult	Subsistance User - Adult	Subsistance User- Child	Combination* Adult Risk
Incidental Soil/Sediment Ingestion	7.4E-7	NA	NA	7.4E-7	0.021	NA	NA	0.021
Soil/Sediment Dermal Contact	4.6E-9	NA	NA	4.6E-9	0.0018	NA	NA	0.0018
Fish Ingestion	NA	1.2E-7	7.5E-9	1.2E-7	NA	0.013	0.0012	0.013
Shellfish Ingestion	NA	2.2E-5	5.1E-6	2.2E-5	NA	0.55	0.19	0.55
Total	7.4E-7	2.2E-5	5.2E-6	2.3E-5	0.023	0.57	0.19	0.59

* Combination includes risks from both subsistance consumption and recreational activity (such as hunting at the site)